Benj. Arnold
Chicago Oct. 18th. 1905

/

TPY
General

These specifications and drawings are submitted as the property of the General Electric Company and as part of its bid. They are confidential communications between the New York, New Haven and Hartford Railroad Company and the General Electric Company, and are to be treated as such.

SPECIFICATIONS

FOR

ELECTRIC LOCOMOTIVES

PROPOSED FOR

New York
New Haven
and Hartford
RAILROAD.

Submitted by

GENERAL ELECTRIC COMPANY
SCHENECTADY, N. Y.

PART I

GENERAL SPECIFICATIONS

FOR

ELECTRIC LOCOMOTIVES

AS ISSUED BY

NEW YORK, NEW HAVEN AND HARTFORD
RAILROAD COMPANY

ELECTRICAL ENGINEER'S OFFICE

GENERAL SPECIFICATIONS

FOR

ELECTRIC LOCOMOTIVES

CONTENTS

The New York, New Haven & Hartford Railroad Company

Electrical Engineer's Office

GENERAL SPECIFICATIONS

FOR

ELECTRIC LOCOMOTIVES

DEFINITIONS:

Wherever the words "Company" or "Contractor" appear in these specifications, they refer respectively to the New York, New Haven & Hartford Railroad Company, and to the successful bidder.

The word " ton" is to be understood to mean two thousand (2,000) pounds.

All train weights are exclusive of locomotive.

GENERAL:

Bids are invited on fifty (50) locomotives. A description of one is to apply to all. They are to be used to haul passenger trains between Woodlawn Junction and Grand Central Station, New York. Should electric operation subsequently be extended to New Haven, they must be suitable for the duty thereby imposed.

The intent of these specifications is to describe the requirements of the service, and to invite bidders to submit their own designs based thereon. Bids should cover all necessary labor, material and tools required to deliver the assembled locomotive connected mechanically and electrically in readiness for operation upon the Company's tracks.

SERVICE:

Attached are:

(a) An official time table of the passenger trains over the New York Division between New York and New Haven. (Station stops average forty-five (45) seconds each.)

(b) Blue prints showing the track alignment and gradients.

(c) A standard car clearance diagram giving the limiting dimensions beyond which no part of the locomotive, excepting the contact devices or collecting current, must project.

The locomotive must be able to haul a train weighing 600 tons between Grand Central Station and New Haven, in either direction, on any schedule given in the attached time table, to continue to repeat this performance with lay-overs of not less than forty-five (45) minutes at New York and thirty (30) minutes at New Haven, and with a temperature rise of not to exceed 75°C., above surrounding air, measured by thermometer, in any part of the electric motors or control apparatus mounted thereon, not including resistance.

The locomotive must be able to perform the service prescribed in the previous paragraph when running at not to exceed 85% of its maximum theoretical schedule speed.

The guage for tangent track is 4 ft. 8½ in., increased to 4 ft. 9½ in. on curves of 230 feet radius.

The rigid wheel base of locomotive must not be greater than thirteen feet.

PERFORMANCE:

Each bidder is asked to state:

(a) What is the quickest schedule this locomotive will make when hauling a 750 ton train, making no stops between Grand Central Station and New Haven, motors to keep within stated temperature limits?

(b) What temperature will the motors reach for one run over the Division under the conditions in the preceding paragraph, after attaining their maximum temperature, in hauling a 600 ton train?

(c) What is the weight of the heaviest train the locomotive will haul when making the most severe schedule in the attached time table, and within the prescribed temperature limits?

As a majority of the Company's trains weigh 300 tons or less, preference will be given to a locomotive divisible into two units, each complete in itself and suitable for hauling a 300 ton train under the hereinbefore prescribed conditions, but which can be quickly coupled to one or, if necessary, two other units for heavier service. When so coupled, the one, two or three units are to be susceptible of operation from the cab of any one as well as any unit may be operated alone.

ENERGY SUPPLY:

Continuous current will be supplied. The normal electromotive force will be 600 volts, the maximum 750 volts. The locomotive must be designed to collect this current either from third rail at the side of the track or from an overhead conductor in the center, varying in height from 14 feet to 22 feet above the top of the track rails.

Alternative tenders are invited on:

1. Locomotive suitable for continuous current operation, as above.
2. Locomotive which may be operated interchangeably on either continuous current or by single-phase alternating current of 3,000 to 3,300 volts, supplied from an overhead conductor.

Preference will be given to the locomotive that can later be adapted to use on 3,000 volt single-phase by the addition of more parts and appliances.

The information asked for under the heading "Performance" and all mechanical and electrical characteristics, run curves, and other description supplied by the bidder should be given for each type of locomotive on which he may tender. In the event of a tender on the interchangeable locomotive, all specifications which are different when the locomotive is operated on the continuous current and when it is operated on the alternating current, should be given fully for each of these conditions of operation.

Two typical run curves should be submitted, showing:

(a) Speed in miles per hour.

(b) Current taken by the locomotive.

(c) Energy taken by the locomotive, both true and apparent.

Calculating the typical run curves the following data must be taken:

First curve:

(a) Train weight, 600 tons.

(b) Schedule speed, 26 miles per hour.

(c) Stops per mile, 0.451.
(d) Length of stop, forty-five (45) seconds.
(e) Track tangent and level.

Second curve:

Conditions the same as for first curve except the weight of train to be 400 tons.

DRAWINGS AND DESCRIPTION:

The bidder will submit drawings of each type of locomotive assembled, showing:

1. Frame.
2. Method of supporting frame.
3. Overall dimensions.
4. Rigid wheel base.
5. Total wheel base.
6. Diameter of wheels.
7. Total weight.
8. Distribution of weight on drivers and on other wheels.
9. Cab.
10. Arrangement of apparatus in cab.
11. Motor assembled.
12. Motors in place on locomotive, giving clearances.
13. Motor suspension.
14. Means of mounting and removal of motors and parts and construction of frame, permitting access for inspection and repairs.

It is desirable that the foregoing information should be combined into as small a number of drawings as practicable. Such additional drawings and photographs are also desired as will assist and complete the description of the principal parts of the motor, control apparatus and all locomotive parts.

Individual motor curves should show:

1. Efficiency.
2. Tractive effort.
3. Speed.
4. Capacity, time and temperature.
5. Power factor.

Curves giving similar characteristics for the complete locomotive are also desired.

The bidder should state:

1. Continuous current capacity of motors at the rated voltage.
2. What current and voltage continuously applied will equal the duty imposed by hauling a 300 ton train between New York and New Haven.
   (a) On the fastest express service.
   (b) On the most severe local schedule.

There should also be submitted the following data:

1. Motor field resistance.
2. Motor armature resistance.
3. Details of armature winding.
4. Details of field winding.
5. Air gap.
6. Diagram of all electrical connections on locomotive.

7. Control wiring diagram.
8. Resistance of each step in the motor rheostats.

HEATERS:

Eighty (80) pounds of steam per car per hour at 5 lb. pressure, are required for heating. The total pressure being equal to 5 lb. times the number of cars in the train. A boiler, water tank, and other heating appliances sufficient to supply heat to a fifteen car train for four hours, must be supplied. Description of the apparatus offered with a statement of the limits of its capacity, method of operation, and dimensions of storage tanks for water and fuel, are desired.

AIR BRAKES:

A motor driven air compressor, with necessary regulator, switch, etc., and having sufficient capacity to supply all the air required for the heaviest duty that the locomotive is designed to perform, shall be supplied.

COMPLEMENT OF PARTS:

All principal and wearing parts of locomotive are to be fitted to guages and templates to insure thorough interchangeability.

The omission herefrom of any necessary parts of the complete locomotive does not relieve the bidder from the responsibility of furnishing them.

The equipment of a half unit shall include the following parts:

1. Two headlights.
2. One bell.
3. One whistle with provision for operation by compressed air.
4. Two drawbars with automatic couplers.
5. Speed indicator.
6. Sanding device.
7. Train signal.
8. Foot plates and steps.
9. Platform buffers.
10. Electrical fittings, including circuit breaker, ammeter and lightning arrester.

PRICE:

The price should include locomotive complete in all details, delivered on the Company's tracks at Woodlawn Junction, N. Y. If the bidder offers a locomotive suitable for interchangeable operation on continuous and on single-phase currents, and if any part or parts of such locomotive essential for operation by alternating current but unnecessary with continuous current may be omitted when the locomotive is first built and later installed, the bidder is asked to enumerate such parts, to give price of locomotive without them, and also the price for which he will on subsequent order, supply and install such part or parts ready for service.

DELIVERY:

Thirty units are required to be delivered by May 1st, 1906. Each bidder must state when he can deliver the first locomotive, and the rate or rates of delivery of subsequent locomotives, including in this statement a stated allowance of time for tests of the first locomotive as hereinafter specified.

TESTS:

On the completion of the motors for the first locomotive, they shall be tested, at the Contractor's shops and at the Contractor's expense, to determine their compliance with the guarantee in the following respects:

1. Efficiency.
2. Torque.
3. Speed.
4. Heating under various loads.
5. Power factor.
6. Commutation and flashing.

Upon the completion of the first locomotive, it is desired that test runs, approximating service conditions, shall be made. The bidder will state what are his track and power facilities for the conduct of such tests.

The Company is to have the right to send representatives at any and all times to inspect the Contractor's work in the Contractor's shops or elsewhere, and to reject any design, labor or material which does not comply with the specifications.

NEW YORK, NEW HAVEN & HARTFORD RAILROAD COMPANY

APPENDIX TO PRELIMINARY SPECIFICATIONS FOR ELECTRIC LOCOMOTIVES

NEW HAVEN, CT., June 12th, 1905.

(A) THE GENERAL ELECTRIC CO.,
New York City.

Attention Mr. Hawks:

Gentlemen:—

Referring to weights on drivers and length of wheel base in which they are included, this letter is to officially confirm our conversation upon this matter and form a part of the specifications now in your hands covering Electric Locomotives for this Company.

The rigid wheel base is not to exceed thirteen (13) feet.

There is not to be concentrated within the above wheel base a weight to exceed 136,000 pounds.

No pair of drivers is to have a weight to exceed 34,000 pounds.

The distance between drivers is not to be less than fifty-two (52) inches.

Yours very truly,
(Signed) WM. S. MURRAY,
Electrical Engineer.

NEW HAVEN, CONN., June 15th, 1905.

(B) MR. W. B. POTTER,
General Electric Company,
Schenectady, N. Y.

Dear Sir:—

We have received from you to-day the following telegram:

"Clearance outline accompanying your locomotive specifications shows four inch clearance for motors above top of rail. We assume this to be with worn tires. Have assumed six inch clearance with new tires to allow for tire wear, are we correct or is less than this allowable if so how much."

To which I have replied:

"Telegram received. Assume not less than six inch clearance for new tires."

The assumptions in the telegram were correct and after conference with our Mechanical Engineer I have been advised that nothing less than six inches can be allowed for new tires. We will advise that a wear of two inches is allowable on the tire and I assume that the original thickness of your tires will permit this wear.

Very truly yours,
(Signed) WM. S. MURRAY,
Electrical Engineer.

PART II

SUPPLEMENTARY SPECIFICATIONS

FOR

ELECTRIC LOCOMOTIVES

AS SUBMITTED BY

GENERAL ELECTRIC COMPANY

SPECIFICATIONS FOR ELECTRIC LOCOMOTIVES

SUBMITTED BY

GENERAL ELECTRIC COMPANY

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INTRODUCTION

INTRODUCTION

GENERAL:

The specifications and drawings of the several types of locomotives submitted herewith are the result of a careful and thorough study of your service conditions and requirements as outlined in your descriptive specifications accompanying request for tender dated May 29th, 1905. In addition, various members of our Engineering Department have inspected the section between New York and New Haven in order to become familiarized with the physical conditions affecting the service. The mechanical features of our designs have been worked out with the assistance of the engineers of the American Locomotive Company, whose experience in high speed locomotive work has been freely drawn upon.

DESIGNS SUBMITTED:

In connection with this and other propositions, we have worked out in detail more than twenty designs of locomotives which would be applicable to your service conditions. While each of these designs has some special features of merit, we are offering only those types which investigation has shown to combine to the best advantage, reliability, efficiency and low maintenance, and whose characteristics are best adapted to the duty expected of them. In all of the designs presented we have borne in mind the probability of the future electrification of your complete system, and the various types, either as they stand or with additions which may be easily and conveniently provided, will be capable of operating either from direct current or from alternating current.

We have considered the possibility of four systems of distribution, namely:

(a) 600 Volts, Direct Current, Third Rail or Overhead Conductor.
(b) 1200 Volts, Direct Current, Overhead Conductor.
(c) 3000 Volts, 25 Cycles, Alternating Current, Overhead Conductor.
(d) 3000 Volts, 12.5 Cycles, Alternating Current, Overhead Conductor.

We are submitting seven designs of locomotives, which for convenience in reference we have numbered consecutively, and which may be identified by the following brief description:

No.	Voltage	Current	Cycles	Tons	Type	Wheel Arrangement
1	600	Direct		97	Gearless	2–8–2
2	600	Direct		75	Gearless	2–8–2
3	1200	Direct		97	Gearless	2–8–2
4	1200	Direct		75	Gearless	2–8–2
5	3000	Alternating	25	145	Geared	2–6–6–2
6	3000	Alternating	12.5	145	Geared	2–6–6–2
7	3000	Alternating	12.5	120	Side rod	2–4–4–2

The 1200 volt direct current locomotives (Nos. 3 and 4) will be similar to the 600 volt locomotives (Nos. 1 and 2) and will be provided with a switch for changing the connections of the master controller for 1200 volt and 600 volt operation.

In case the 1200 volt D.C. system is chosen for the equipment of the permanent way between Woodlawn and New Haven, the switch would be thrown at Woodlawn for operation on 600 volts between Woodlawn and Grand Central Station.

MECHANICAL CONSTRUCTION:

Gearless Direct Current Type

The direct current locomotives Nos. 1, 2, 3 and 4 will all be of the Gearless type, a design which we have developed for high speed heavy passenger work. This type of locomotive consists of a rigid truck with four driving axles and a two wheel guiding truck at each end. The motors are bipolar, one for each driving axle, the truck framing forming part of the magnetic circuits of the motors. The weight of the truck frame is carried on springs attached to spring saddles over the journal boxes, and the poles are so shaped that the armature is free to move between them with ample clearance on the sides as the poles move up and down with the riding of the truck on the frame.

The armature is mounted rigidly upon the axle. The dead weight per axle, however, is not greater than it is customary to use with steam locomotives, being 12,520 lb. for locomotive No. 1 and 10,670 lb. for locomotive No. 2. As there is no unbalanced weight on the drivers to produce vibration, the strains in the road bed will be materially reduced, with consequent reduction in cost of maintenance.

This type of locomotive has been given an exhaustive series of tests on the experimental tracks at Schenectady, in which its excellent riding qualities at speeds reaching 85 M.P.H. have been demonstrated, and its accelerating and service capacity under a wide range of service conditions determined.

Geared Alternating Current Type

Owing to limitations in electrical design, the alternating current motor is not adapted to direct mounting on the axle and it is consequently necessary to drive the axles through intermediate mechanism. The capacity called for requires the use of six motors for the geared type of locomotive (Nos. 5 and 6). We propose to mount these motors on a six wheel articulated or hinged frame with a two wheel guiding truck of the radius bar type at each end. We consider the use of these guiding trucks necessary for safe running at the high operating speed required.

We are offering motors of two frequencies for this type of locomotive, namely, 25 cycles and 12.5 cycles per second, the lower frequency giving advantages in the way of better commutation, improved motor characteristics and service capacity.

Side Rod Type

As an alternative to the geared type of alternating current locomotive, we are offering a locomotive (No. 7) in which power will be transmitted from the motor to the axle through a system of cranks and connecting rods. This locomotive will consist of a four axle articulated frame with a pony truck at each end. Each half of the articulated truck will carry a single-phase alternating current motor on a steel frame work bolted to the truck framing, and power will be transmitted from the armature of the motor to an intermediate shaft midway between two driving axles by means of a crank and connecting rod. These two axles will be coupled together with connecting rods on each side and driven by a crank and a rod connecting the intermediate shaft to one of the driving wheels.

ADVANTAGES OF THE GEARLESS DIRECT CURRENT TYPE:

The following advantages are claimed for the gearless design as submitted herewith :

1. Low maintenance charges, due to the absence of motor bearings and gears, accompanied by excellent commutation and low temperature.

2. Facility in making repairs or renewals. The armature with its wheels and axles may be removed by lowering the complete element without disturbing the fields or any other part of the locomotive and a new element inserted in its place.
3. Ease of inspection.
4. Reliability in operation due to small number of parts subjected to wear or to heavy strains.
5. High efficiency under wide range of service conditions.
6. Superior riding and running qualities.
7. High accelerating capacity.
8. Large power per axle with minimum weight for given service.

DIRECT CURRENT AND ALTERNATING CURRENT OPERATION:

Any of the alternating current locomotives offered may be operated interchangeably on either continuous current or single-phase alternating current of 3000 to 3300 volts supplied from an overhead conductor without change in the design of equipment proposed.

The capacity of the alternating current compensated motor when operating on direct current, will be considerably greater than when operating on alternating current. It should be noted, therefore, that for direct current service only, between Grand Central Station and Woodlawn, locomotives Nos. 5 and 6 would only be equipped with four motors each. The horse-power ratings of the alternating current locomotives Nos. 5, 6 and 7 on direct current only, and their weights are as follows:

Locomotive No.	5	6	7
Motor	GEA-607	GEA-608	GEA-609
No. of motors, direct current only	4	4	2
Total horse-power, direct current only	1300	1300	1500
Tons, direct current only	118	120	110

The direct current service between Grand Central Station and Woodlawn will require a maximum speed not to exceed 50 m.p.h.

It may be of interest to note that if this were the only service to be handled, a 60 ton bogie truck locomotive, equipped with four 300 h.p. D.C. motors, either gearless or geared, with a maximum speed of 50 m.p.h. would be capable of satisfactorily handling the service.

ELECTRIC TENDER:

The Gearless type of locomotive (equipped with direct current motors) may be operated from single-phase alternating current of 3300 volts or higher, delivered by an overhead trolley, by adding to the equipment of each locomotive a motor generator set for changing the 3300 volt single-phase alternating current into 600 volt direct current suitable for the operation of the motors. This motor generator set will be carried in a tender which may be coupled to one of the gearless locomotives, forming a combination which in the present instance will weigh less than a locomotive of equal capacity equipped with alternating current geared motors, and will at the same time retain all of the advantages of the direct current gearless locomotive. As shown later, the service efficiency of a gearless locomotive with tender when running on alternating current will be superior to that of the single-phase locomotive designed for 25 cycles and almost as good as that for 12.5 cycles. This combination possesses the further advantage that for your initial equipment required for the service between Grand Central Station and Woodlawn, a thoroughly delevoped and standard type of locomotive of high efficiency and minimum weight may be purchased. If future development should require the use of alternating current on other parts of your system, the addition of the electric tender will enable the locomotive to be operated at high efficiency and low maintenance at any practicable trolley voltage and at any convenient frequency.

MOTORS:

The several types of locomotives which we are proposing have made necessary the production of a number of designs of motors, each of which is especially adapted to the type of locomotive with which it is to be used.

Characteristic curves are shown for each type of motor, and the rating and general dimensions are given in the motor specifications.

The electric motors, both alternating and direct current, will be designed and built in accordance with the best accepted practice in railway motor manufacture. Both types will be series wound and will have similar speed and torque characteristics. The alternating current motor, however, will differ from the direct current type in certain particulars which may be briefly enumerated as follows:

The field will be built up of sheet iron laminations slotted uniformly throughout the periphery to receive the conductors. There will be two distinct windings, both connected in series with the armature. One of these windings will be so located as to produce the desired magnetic flux through the armature. The second or compensating winding will be magnetically displaced 90 degrees from the first field winding and will be so proportioned as to completely neutralize the cross magnetizing flux due to the current in the armature. By the use of this type of winding, the armature reaction is neutralized at all loads and good commutation is obtained without the use of high resistance leads between the armature winding and commutator. It possesses the further advantage that compensation is secured on either direct or alternating current so that the motor will operate on direct current with practically sparkless commutation.

The armature construction is similar to that of the ordinary railway motor, and the absence of high resistance leads is attended with increased efficiency and avoidance of excessive local temperatures.

SERVICE CAPACITY

Running Time

From the official time table accompanying your specifications, the quickest run between New York and New Haven is made by train No 10 making no stops, the running time being one hour and 38 minutes. The most severe local schedule is represented by train No. 278 making 28 intermediate stops between New York and New Haven, the running time being two hours and 41 minutes.

Speed Limitations

The speed limitations between 42d St. and Woodlawn, as fixed by the New York Central & Hudson River Railroad, are:

Section	Length	Maximum Speed
G. C. S. Train shed	570 ft.	6 M.P.H.
G. C. S. Yard	3062 ft.	25 M.P.H.
56th St. to 96th St.	10666 ft.	45 M.P.H.
96th St. to 132d St.	9451 ft.	45 M.P.H.
132d St. curve	500 ft.	25 M.P.H.
Harlem River bridge.	400 ft.	25 M.P.H.
Bridge to 138th St.	1257 ft.	45 M.P.H.
Mott Haven Jct.	855 ft.	25 M.P.H.

Between Woodlawn and New Haven, as given on your blue print, the speed limitations are:

Section	Length	Maximum Speed
Going East slow down to 8 m.p.h. at Woodlawn		
Harlem River Branch Junction	400 ft.	30 M.P.H.
Mianus Bridge	3000 ft.	30 M.P.H.
Norwalk Bridge	1500 ft.	30 M.P.H.
Bridgeport Curve	700 ft.	35 M.P.H.
Hequonnock Bridge	500 ft.	25 M.P.H.
Hequonnock Curve	400 ft.	35 M.P.H.
New Haven Yards	1500 ft.	6 M.P.H.

EXPRESS TRAINS:

Based on the speed limitations as given above and braking at the rate of 1¼ miles per hour per second as authorized, the following table shows the performance and data required by your specifications for the various types of locomotives upon which we are bidding, when running from New York to New Haven on fastest schedule without stops, as represented by express train No. 10.

	LOCOMOTIVES				
	Nos. 1 and 3	Nos. 2 and 4	No. 5	No. 6	No. 7
600 Tons Trailing Load, Two Locomotives					
Required time, minutes	98	98	98	98	98
Maximum theoretical schedule, minutes	68	79.2	75	75.6	72.2
Ratio, required to theoretical schedule	69.4%	81%	76.5%	77.2%	73.7%
Estimated time including speed limitations	83	91.6	88	86	85
Estimated temperature rise, continuous operation, including lay overs					
Armature, degrees C.	60	66	60	51	50
Field, degrees C.	40	41	50	40	45
Square root of mean square current based on required schedule, amperes	343	239	700	360	840
Effective volts	475	520	172	335	440
750 Tons Trailing Load, Two Locomotives					
Estimated time, minutes	85	95	91	91	88
Estimated temperature rise, one trip, succeeding all day service with 600 ton trains, degrees C.	70	75	75	70	70
Weight heaviest train operating all day, 75 degrees C. rise, tons	750	600	600	750	750

LOCAL TRAINS:

Based on the most severe local schedule, as represented by train No. 278, in which 28 stops are made between New York and New Haven, speed limitations being as given above and braking at the rate of 1¼ miles per hour per second as authorized, the estimated performances of the various types of locomotives proposed are as follows:

	LOCOMOTIVES				
	Nos. 1 and 3	Nos. 2 and 4	No. 5	No. 6	No. 7
600 Tons Trailing Load, Two Locomotives					
Required time, minutes	161	161	161	161	161
Maximum theoretical schedule, minutes	134.2	142	157	146	149
Ratio, required to theoretical schedule	83.5%	88.2%	97.5%	90.6%	92.6%
Estimated time including speed limitations	143	149	165	153	157
Estimated temperature rise, continuous operation including lay overs					
Armature, degrees C.	70	85	85	75	75
Field, degrees C.	75	90	65	60	60
Estimated temperature rise after eight hour starting cold					
Armature, degrees C.	58	70	81	71	71
Field, degrees C.	62	75	62	58	58
Square root of mean square current, based on required schedule, amperes	460	352	1040	600	1300
Effective volts	300	410	154	250	300
400 Tons Trailing Load, Two Locomotives					
Required time, minutes	161	161	161	161	161
Maximum theoretical schedule, minutes	126	134	142.5	136	139
Ratio, required to theoretical schedule	78.2%	83.3%	88.6%	84.5%	86.3%
Estimated time including speed limitations	138	144	154	146	150
Estimated temperature rise, continuous operation, including lay overs					
Armature, degrees C.	58	72	68	62	62
Field, degrees C.	60	75	50	45	45
Estimated temperature rise after eight hours, starting cold					
Armature, degrees C.	48	59	65	60	68
Field, degrees C.	49	62	48	43	54
Square root of mean square current, based on required schedule, amperes	410	312	900	580	1200
Effective volts	310	425	168	275	325
Weight heaviest train operating all day, 75 degrees C. rise, tons	600	400	480	600	600

FORCED VENTILATION:

The estimated temperature rises for alternating current motor locomotives Nos. 5, 6 and 7 are based on the use of forced ventilation, which is provided for in the equipment. The temperature rises for locomotives Nos. 1, 2, 3 and 4 are based on natural ventilation, and if forced ventilation is used, it is estimated that these temperatures could be reduced 25 per cent. We consider the temperature rises shown for locomotives Nos. 1, 2, 3 and 4 without forced ventilation to be entirely safe even for such abnormal operation as is likely to occur in service.

In the above estimates, locomotives Nos. 1 and 2 are assumed to be operating without electric tender. If tender is added the running time in local service would be increased 3 per cent. and the heating of the locomotives 15 per cent. In the express service, the time need not be increased as the D.C. voltage of the generator could be regulated according to the requirements.

ENERGY CONSUMPTION:

We direct attention to the relative service efficiencies of the several types of locomotives as shown by the speed time and energy curves prepared for representative run of 2.21 miles in 262 seconds, length of stop 45 seconds, schedule speed 26 miles per hour.

	Total Weight Train Tons	Watt-Hrs. Per Ton-Mile	Kw. Hrs. Per Train Mile
600 Ton Train, 2 Locomotives			
Locomotive No. 1, D.C.	794	37.2	29.5
2, D.C.	750	35.2	26.4
1, A.C. (with tender).	934	35.6	33.2
2, A.C. (with tender).	860	37.3	32.1
5, A.C.	890	48.7	45.2
6, A.C.	890	33.1	29.9
7, A.C.	840	38.2	32.1
400 Ton Train, 2 Locomotives			
Locomotive No. 1, D.C.	594	36.1	21.4
2, D.C.	550	33.	18.2
1, A.C. (with tender).	734	34.	25.0
2, A.C. (with tender).	660	35.3	23.3
5, A.C.	690	38.5	26.3
6, A.C.	690	31.8	21.9
7, A.C.	640	35.0	22.4

The energy consumption of locomotives Nos. 3 and 4 will be approximately the same as given for locomotives Nos. 1 and 2 operating on direct current.

The relative economy of the several types of locomotives is indicated by the kilowatt hours per train mile, as this term measures the total input to the train including the locomotive.

Attention is directed to the performance of locomotive No. 2, which it will be seen is capable of hauling 600 ton trailing load on express service, and 400 ton trailing load on local service on schedule time and with temperature rise not

exceeding 75 degrees C. This locomotive is also the most efficient under service operation, as shown by table above, and by reason of the absence of gearing possesses advantages in the way of simplicity and low maintenance.

POWER AND TRACK FACILITIES FOR TESTING:

The General Electric Company has available at all times for testing heavy locomotives, a 2000 Kw. Curtis turbine, which is installed solely for this purpose in the new power house at Schenectady.

The track facilities consist of six miles of single track on the New York Central line between Schenectady and Hoffmans. This track is supplied with power from a sub-station containing a 1500 Kw. 650 volt rotary converter, receiving current at 11,000 volts from the above mentioned Curtis turbine.

In addition to the above, the General Electric Company has 6000 feet of track laid along the bank of the Erie Canal adjacent to the Schenectady Works. This track is supplied with power by the 2000 Kw. Curtis turbine above mentioned.

NOTE: All of our calculations are based on a service rate of braking of 1¼ miles per hour per second. If, for purposes of estimating, we are allowed to use a higher rate, there will be a material reduction shown in the running time, energy consumption and heating data, as given for the local service. Any comparison of possible performances of locomotives must be based on similar conditions as to braking.

SPECIFICATIONS

SPECIFICATIONS FOR ELECTRIC LOCOMOTIVES

GENERAL DESCRIPTION

GENERAL:

The several types of locomotives which we are offering have been designed to successfully meet the service requirements and conditions of operation given in your preliminary specifications and data accompanying request for tender dated May 29th, 1905.

In the details of construction and of the equipment of the locomotives, every effort has been made to eliminate as far as possible all sources of weakness that might eventually interrupt the service.

CAB:

The cabs have been designed with special reference to securing convenience in operation and adequate housing of the apparatus. Entrance may be gained through doors at the sides or ends, and there will be a central corridor running throughout the length of the cab so as to afford convenient communication between coupled locomotives, or between a locomotive and the rest of the train. The windows will be large and so placed as to give practically an unobstructed view of the track in front or rear. The wood used in the construction of doors and sashes will receive thorough fireproofing treatment.

FRAMING:

The framing will be constructed of cast steel, the side and end frames being bolted together with body-bound bolts at machined surfaces, and stiffened by cast steel cross transoms. The sections of the frame will be designed to give the greatest strength consistent with the amount of material used. Journal boxes and axles will permit sufficient lateral play to enable the locomotive to pass easily around curves of 230 ft. radius; the track guage at such points being 4 ft. 9½ in. The rigid wheel base will not exceed 13 ft.

PONY TRUCKS:

The pony trucks will be similar to the standard locomotive construction, namely a radial truck pivoted by means of radius bars to a point beneath the locomotive. The truck will be free to swing about its center and will be self-centering on a straight track. Side springs and rubbing plates will be used to assist the guiding action and prevent any tendency to nosing.

EQUALIZATION:

Proper distribution and division of the weight of the locomotives amongst the axles will be accomplished by swinging the main frames from a system of half elliptic springs and equalized levers of forged steel or iron, the whole being so arranged as to cross equalize the load and furnish three points of support.

WHEELS AND AXLES:

The wheels will have M.M. standard tread and flange. The distance between the backs of the flanges will be 4 ft. 5⅜ in. The wheels will be of cast steel, spoke center pattern with steel tires 3½ in. thick for driving wheels and 3⅛ in. thick for pony truck wheels, held by retaining rings. All tires will be flanged.

All axles will be of sufficient size to give large factors of safety in proportion to the weight of the various types of locomotives.

JOURNALS AND JOURNAL BOXES:

The journals and journal boxes will be of approved standard construction.

SPRINGS:

The springs will be made of crucible steel. Their general arrangement is shown on locomotive drawings.

BRAKES:

Each locomotive will be equipped with complete standard quick action, high speed, automatic air brake apparatus consisting of two engineer's valves, two air guages, one plain triple valve, brake cylinders, and one auxiliary reservoir; all of ample capacity with necessary main reservoir, drip cups, strainers, etc.

The air compressor will be of the vertical cylinder direct coupled type with a piston displacement of 75 feet per minute. It will be capable of supplying air at 130 lb. pressure, sufficient for operating the brakes throughout the train with ample allowance for whistling and signaling.

FOUNDATION BRAKES:

The foundation brakes will be of standard locomotive type, cross-equalized, applied to the driving wheels and so arranged that all of the brake shoes will press equally against the same side of the wheels, ensuring equal braking power at all times on each of the wheels.

MOTORS:

Description of motors and number required for each design of locomotive are given under "Motor" and "Detail Locomotive" specifications.

CONTROL:

The Sprague-General Electric Multiple Unit Control System will be used and is described under the "Control" specifications.

THIRD RAIL SHOES:

On the sides at each end of the locomotive will be placed spring contact third rail shoes suitable for the collection of the necessary current, and these will be so spaced as to give considerable distance between them to allow for bridging the third rail at cross overs and special work. They will be carried at the ends of beams bolted to the framing. A shoe fuse will be placed upon each beam where it can be quickly inspected.

OVERHEAD CONTACTS:

The overhead shoes will be placed near the ends of the cabs on well insulated platforms. The cables will be led through suitably protected holes in the roof.

WHISTLE:

The whistle will be of the chime or other approved pattern, made of polished brass, and will be complete with all connections to air reservoir.

BELL:

A suitable bell with an approved form of air ringer with all connections will be provided.

HEAD LIGHT:

The locomotive will have at each end an electric headlight with 16 in. reflector, and equipped with a light of suitable candle power.

SANDING DEVICE:

At each end of the locomotive and formed in the cab housing will be provided sand boxes of ample size opening through the roof and having suitable covers. The sand boxes will be fitted with approved pneumatic sanding devices with air pipes arranged so that sand is delivered to the forward driving wheels of the locomotive while running in either direction. This device is controlled by means of electrically operated valves and may be operated at any master controller, sanding the wheels on either a single locomotive or on two or more simultaneously when coupled together.

A hand device will also be provided to furnish sand to the forward driving wheels of the single locomotive at the end from which the device is operated.

TRAIN SIGNAL:

Each locomotive will be equipped with standard pneumatic signal apparatus with proper connections.

DRAW BARS AND COUPLERS:

There will be provided at each end of the locomotive an M.C.B. vertical plane automatic coupler so arranged as to allow ample lateral movement for crossings of 230 ft. radius.

FOOT PLATES AND STEPS:

Running boards, foot plates and steps will be supplied where necessary to give access to all parts of the locomotive.

BUFFERS:

Buffers will be provided at each end of the locomotive to conform with the Railroad Company's practice, and of an approved form.

PILOT:

The pilot will be made of iron and of a design acceptable to the Railroad Company.

TOOLS:

There will be furnished with each locomotive the following tools, all of approved form and manufacture:

4–Arm rests.
1–Flat chisel.
1–Cape chisel.
1–1-Gallon oil can.
1–2-Gallon oil can.
2–Padlocks.
1–15″ Monkey wrench.
1–Alligator wrench.
2–Plain jack screws.
2–Plain jack screw levers.
2–Buckets.
1–Soft hammer.
1–Steel hammer.
1–Packing hook.
1–Pinch bar.
1–Packing iron.
1–Set wrenches, brake equip.
5–Fin. Hex. $\frac{3}{8}''$ to $1\frac{1}{2}''$ wrenches.
1–Fin. sq. $\frac{1}{2}''$ and $\frac{5}{8}''$ wrench.
2–White flags.
2–Green flags.
1–Red flag.

LOCOMOTIVE NO. 1

DETAIL SPECIFICATIONS

Four GE–84 Gearless Direct Current Motors, with pony trucks (radius bar type).

Voltage	600
No. of driving wheels	8
Diameter of driving wheels	44 in.
Diameter of pony truck wheels	36 in.
Total wheel base	27 ft.
Rigid wheel base	13 ft.
Length over buffers	37 ft.
Length of steel cab	34 ft.
Height of steel cab	13 ft. 9 in.
Height to top of hood	14 ft. 4 in.
Width overall	10 ft. 1 in.
Width of steel cab	10 ft.
Diameter of driving axle	$8\frac{19}{32}$ in.
Size of driving axle journal	7in. x 14 in.
Diameter of pony truck axle	$6\frac{1}{2}$ in.
Size of pony truck journal	$6\frac{1}{2}$ in. x 14 in.
Weight of locomotive complete	194,000 lb.
Weight of locomotive on drivers	136,000 lb.
Weight of locomotive per driving wheel	17,000 lb.
Weight of locomotive per driving wheel (dead weight)	6,260 lb.
Weight of locomotive per pony truck	29,000 lb.
Outline drawing	T–120476

LIST OF APPARATUS:

4–GE–84 motors.
1–Motor driven air compressor with air compressor governor.
Necessary switches, fuses, etc.
1–Complete control equipment.
1–Flash boiler heating plant.
1–Bell.
1–Whistle.
2–100 C.P. incandescent headlights.
1–Complete air brake equipment for straight and automatic air with two engineers' valves and two gauges.
1–Electro-pneumatic sanding device.
2–Ammeters.
2–Draw bars with automatic couplers.
1–Speed indicator.
1–Train signal.
Foot plates and steps.
Platform buffers.

LOCOMOTIVE NO. 2

DETAIL SPECIFICATIONS

Four GE–94 Gearless Direct Current Motors, with pony trucks (radius bar type).

Voltage	600
No. of driving wheels	8
Diameter of driving wheels	40 in.
Diameter of pony truck wheels	33 in.
Total wheel base	26 ft.
Rigid wheel base	12 ft.
Length over buffers	35 ft.
Length of steel cab	32 ft. 6 in.
Height of steel cab	12 ft. 1 in.
Height to top of hood	12 ft. 8 in.
Width overall	10 ft. 1 in.
Width of steel cab	9 ft. 6 in.
Diameter of driving axle	7½ in.
Size of driving axle journal	6 in. x 12 in.
Diameter of pony truck axle	6 in.
Size of pony truck journal	6 in. x 12 in.
Weight of locomotive complete	150,000 lb.
Weight of locomotive on drivers	110,000 lb.
Weight of locomotive per driving wheel	13,750 lb.
Weight of locomotive per driving wheel (dead weight)	5,335 lb.
Weight of locomotive per pony truck	20,000 lb.
Outline drawing	Photo. No. 202948

LIST OF APPARATUS:

4–GE–94 motors.
1–Motor driven air compressor with air compressor governor.
Necessary switches, fuses, etc.
1–Complete control equipment.
1–Flash boiler heating plant.
1–Bell.
1–Whistle.
2–100 C.P. incandescent headlights.
1–Complete air brake equipment for straight and automatic air with two engineers' valves and two gauges.
1–Electro-pneumatic sanding device.
2–Ammeters.
2–Draw bars with automatic couplers.
1–Speed indicator.
1–Train signal.
Foot plates and steps.
Platform buffers.

LOCOMOTIVE NO. 3

DETAIL SPECIFICATIONS

Four GE–84 Gearless Direct Current Motors, with pony trucks (radius bar type).

This locomotive will be indentical with locomotive No. 1 with the exception of modifications in the control equipment adapting it to operation on 1200 volts direct current as shown in the Control Specifications.

LOCOMOTIVE NO. 4

DETAIL SPECIFICATIONS

Four GE–94 Gearless Direct Current Motors, with pony trucks (radius bar type).

This locomotive will be identical with locomotive No. 2 with the exception of modifications in the control equipment adapting it to operation on 1200 volts direct current as shown in the Control Specifications.

LOCOMOTIVE NO. 5

DETAIL SPECIFICATIONS

Six GEA–607 Geared Alternating Current Motors with Articulated Frame.

Voltage	3300
Cycles	25
No. of driving wheels	12
Diameter of driving wheels	56 in.
No. of pony truck wheels	4
Diameter of pony truck wheels	36 in.
Total wheel base	43 ft. 11 in.
Rigid wheel base	10 ft. 11 in.
Length over buffers	53 ft.
Length of steel cab, each half	24 ft.
Height of steel cab	13 ft.
Height to top of hood	13 ft. 7 in.
Width overall	10 ft. 1 in.
Width of steel cab	10 ft.
Diameter of driving axles	$9\frac{1}{2}$ in.
Size of driving axle journal	7 in. x 14 in.
Diameter of pony truck axle	6 in.
Size of pony truck journal	6 in. x 12 in.
Weight of locomotive complete	286,000 lb.
Weight of locomotive on drivers	226,000 lb.
Weight of locomotive per driving wheel	18,833 lb.
Weight of locomotives per driving wheel (dead weight)	7,525 lb.
Weight of locomotive per pony truck	30,000 lb.
Outline drawing	T–120593

LIST OF APPARATUS:

6—GEA–607, 25 cycle, single phase motors. (Omit 2 motors if not run A.C.)
2–330 Kw. 25 cycle air blast compensators. (Omit if not run A.C.)
2—Motor driven blower sets.
1—Motor driven air compressor with air compressor governor.
Necessary switches, fuses, etc.
1—Complete control equipment.
1—Flash boiler heating plant.
1—Bell.
1—Whistle.
2—100 C.P. incandescent head lights.
1—Complete air brake equipment for straight and automatic air with two engineers' valves and two gauges.
1—Electro-pneumatic sanding device.
2—Ammeters.
2—Voltmeters.
2—Draw bars with automatic couplers.
1—Speed indicator.
1—Train signal.
Foot plates and steps.
Platform buffers.

LOCOMOTIVE NO. 6

DETAIL SPECIFICATIONS

Six GEA–608 Geared Alternating Current Motors with Articulated Frame.

Voltage	3300
Cycles	12.5
No. of driving wheels	12
Diameter of driving wheels	56 in.
No. of pony truck wheels	4
Diameter of pony truck wheels	36 in.
Total wheel base	43 ft. 11 in.
Rigid wheel base	10 ft. 11 in.
Length over buffers	53 ft.
Length of steel cab, each half	24 ft.
Height of steel cab	13 ft.
Height to top of hood	13 ft. 7 in.
Width overall	10 ft. 1 in.
Width of steel cab	10 ft.
Diameter of driving axles	$9\frac{1}{2}$ in.
Size of driving axle journal	7 in. x 14 in.
Diameter of pony truck axle	6 in.
Size of pony truck journal	6 in. x 12 in.
Weight of locomotive complete	290,000 lb.
Weight of locomotive on drivers	230,000 lb.
Weight of locomotives per driving wheel . . .	19,166 lb.
Weight of locomotive per driving wheel (dead weight)	7,525 lb
Weight of locomotive per pony truck	30,000 lb.
Outline drawing	T–120593

LIST OF APPARATUS:

6–GEA–608, 12.5 cycle motors. (Omit 2 motors if not run A.C.)
2—320 Kw. air blast compensators. (Omit if not run A.C.)
2—Motor driven blower sets.
1—Motor driven air compressor with air compressor governor.
Necessary switches, fuses, etc.
1—Complete control equipment.
1—Flash boiler heating plant.
1—Bell.
1—Whistle.
2—100 C.P. incandescent head lights.
1—Complete air brake equipment for straight and automatic air with two engineers' valves and two gauges.
1—Electro-pneumatic sanding device.
2—Ammeters.
2—Draw bars with couplers.
1—Speed indicator.
1—Train signal.
Foot plates and steps.
Platform buffers.

LOCOMOTIVE NO. 7

DETAIL SPECIFICATIONS

Two GEA–609 Direct Coupled Alternating Current Motors.

Voltage	3300
Cycles	12.5
No. of driving wheels	8
Diameter of driving wheels	60 in.
No. of pony truck wheels	4
Diameter of pony truck wheels	36 in.
Total wheel base	40 ft. 6 in.
Rigid wheel base	8 ft. 6 in.
Length over buffers	47 ft.
Length of steel cab, each half	21 ft. 3 in.
Height of steel cab	12 ft. 5 in.
Height to top of hood	13 ft.
Width overall	10 ft. 1 in.
Width of steel cab	10 ft.
Diameter of driving axles	8 in.
Size of driving axle journal	8 in. x 14 in.
Diameter of pony truck axle	6 in.
Size of pony truck journal	6 in. x 12 in.
Weight of locomotive complete	240,000 lb.
Weight of locomotive on drivers	180,000 lb.
Weight of locomotive per driving wheel	22,500 lb.
Weight of locomotive per driving wheel (dead weight)	4,025 lb.
Weight of locomotive per pony truck	30,000 lb.
Outline drawing	T–120557

LIST OF APPARATUS:

2—GEA–609, 12.5 cycle motors.
3–320 Kw. air blast compensators. (Omit if not run A.C.)
2—Motor driven blower sets. (Omit if not run A.C.)
1—Motor driven air compressor with air compressor governor.
Necessary switch, fuses, etc.
1—Complete control equipment.
1—Flash boiler heating plant.
1—Bell.
1—Whistle.
2—100 C.P. incandescent headlights.
1—Complete air brake equipment for straight and automatic air with two engineers' valves and two gauges.
1—Electro-pneumatic sanding device.
2—Ammeters.
2—Draw bars with automatic couplers.
1—Speed indicator.
1—Train signal.
Foot plates and steps.
Platform buffers.

SPECIFICATIONS FOR ELECTRIC TENDERS

These tenders are intended for use with the 600 volt direct current locomotive, and their function will be to receive single-phase alternating current from an overhead trolley at a potential of 3300 volts and to convert same into direct current of 600 volts suitable for the operation of the direct current motors. Each tender is therefore practically a portable sub-station with an overhead collecting device and suitable couplings for making electrical connection to the locomotives. The alternating current will be transformed into direct current by means of a motor generator set consisting of single-phase induction motor mounted on common base and driving a 600 volt direct current generator, the characteristics of the set as regards maximum output, commutation, and heating conforming to those of the motors which they will supply.

CAB AND PLATFORM:

The platform of the tender will consist of a frame work of structural steel for carrying the electrical apparatus with longitudinal members and cross members substantially braced and riveted together by means of suitable knees and gussets. The platform will be covered with a flooring of $\frac{3}{16}$ in. steel.

The cab will be built up of sheet steel $\frac{1}{8}$ in. thick braced by angle and channel irons and fastened to the platform by means of bolts. Doors and window sashes of the cab to be of ash, glass to be of first quality, double thick, and so located as to give adequate illumination of the interior. The general dimensions of the cab are shown under "Detail Specifications for Steel Cab D."

TRUCKS:

There will be two four-wheel swivel trucks, diamond frame pattern, with cast steel bolsters carried by double elliptic springs. In general design the truck will be similar to the swivel truck used under heavy steam locomotive tenders.

WHEELS AND AXLES:

The wheels will have MCB standard tread and flange, and will be of cast steel spoke center pattern with steel tires held by retaining rings.

The axles will be of sufficient size to give large factors of safety in proportion to the weight carried by them.

JOURNALS AND JOURNAL BOXES:

The journals and journal boxes will be of approved standard pattern.

SPRINGS:

The springs will be of crucible steel. Their general arrangement is shown on tender drawings.

BRAKES:

Each tender will be equipped with automatic air brake apparatus consisting of triple valves, brake cylinders, auxiliary reservoirs, brake shoes, and brake rigging, all of ample capacity. Hand brakes will be provided on each tender.

DRAW BARS AND COUPLERS:

At each end of the tender will be provided an MCB vertical plane automatic coupler so arranged as to permit ample lateral movement.

BUFFERS:

Buffers will be provided at each end of the tender to conform with the Railroad Company's practice, and of a form approved by the engineers.

ELECTRICAL EQUIPMENT:

Each tender will be equipped with the following electrical apparatus:

1–two bearing motor generator set consisting of 3300 volt single-phase induction motor and 600 volt D.C. generator with direct connected exciter, mounted upon the "I" beam frame work.

1–resistance-reactance starting device.

2–trolleys of the pantagraph type, pneumatically controlled, one at each end of the tender.

2–high tension fuses for protection of 3300 volt circuit.

1–3300 volt motor panel equipped with ammeter, voltmeter, S.P.S.T. oil switch, D.P.S.T. oil switch, suitable current and potential transformers.

1–generator panel with circuit breaker, ammeter, voltmeter, field rheostat, S.P.S.T. field switch, S.P.S.T. main switch, S.P.S.T. 100 ampere lighting switch.

1–S.P. 4000 volt lightning arrester.

1–Sprague-General Electric multiple unit potential control equipment as per specifications.

Lighting wiring.

Main power wiring, ending in suitable couplers for coupling the power circuits of the tender to the main bus-line of the locomotive.

ELECTRIC TENDER

For Locomotive No. 1

DETAIL SPECIFICATIONS

DIMENSIONS:

Two four-wheel swivel trucks.

Diameter of wheels	36 in.
Total wheel base	20 ft.–8 in.
Bogie truck wheel base	5 ft.–10 in.
Distance between truck centers	14 ft.–10 in.
Length over buffers	27 ft.–6 in.
Length of steel cab	25 ft.–6 in.
Height of steel cab	12 ft.–0 in.
Width overall	10 ft.–1 in.
Width of steel cab	10 ft.–0 in.
Diameter of axles	6 in.
Size of axle journals	6 in. x 12 in.
Weight of tender complete	140,000 lb.
Weight per bogie truck	70,000 lb.
Outline drawing	T–120603

CAPACITY AND RATING:

Rated capacity of motor-generator set	900 Kw.
Direct current voltage of generator	600 volts
Alternating current voltage of motor	3300 "
Cycles	25

Type of motor, single-phase induction.

ELECTRIC TENDER

For Locomotive No. 2

DETAIL SPECIFICATIONS

DIMENSIONS:

Two four-wheel swivel trucks.

Diameter of wheels	36 in.
Total wheel base	20 ft.–8 in.
Bogie truck wheel base	5 ft.–10 in.
Distance between truck centers	14 ft.–10 in.
Length over buffers	27 ft.–6 in.
Length of steel cab	25 ft.–6 in.
Height of steel cab	12 ft.–0 in.
Width overall	10 ft.–1 in.
Width of steel cab	10 ft.–0 in.
Diameter of axles	5½ in.
Size of axle journals	5½ in. x 10 in.
Weight of tender complete	110,000 lb.
Weight per bogie truck	55,000 lb.
Outline drawing	T–120656

CAPACITY AND RATING:

Rated capacity of motor generator set	650 Kw.
Direct current voltage of generator	600 volts
Alternating current voltage of motor	3300 "
Cycles	25

Type of motor, single-phase induction.

SPECIFICATIONS

FOR

LOCATION OF APPARATUS

GENERAL:

In the location of apparatus special effort will be made to secure the greatest simplicity and convenience in operation and inspection. To this end practically all of the auxiliary and controlling apparatus will be carried within the cab. At each end of the cab, in front and on the sides, will be large windows so arranged that the line of vision from the controlling point to the tracks in front and rear is practically unobstructed.

OPERATOR'S CONTROLLING DEVICES:

At opposite corners of the cab between the front and side windows, the chief controlling apparatus will be located and compactly arranged for easy and ready manipulation. The Engineer's brake valve and the switches and valves for operating the sanding, whistling and bell ringing devices are placed by the side of the master controller. On the cab wall in full view of the operator, will be the air guage and the ammeter, with the control circuit switch within easy reach.

The lighting of the cab is so arranged that in running at night illumination may be limited to a small beam of light directed against the scales of the ammeter and air guage, and shielded from the operator's eyes.

There will be a drop cushion seat for the operator, and from this seat the chief control apparatus may be easily manipulated while a practically unobstructed view to the front and rear may be obtained through the windows.

CONTROL EQUIPMENT:

Arranged along the sides of the corridor at the ends of the cab will be the contactors, rheostats and reversers in long boxes of sheet steel sheathed where necessary on the inside with fireproof insulating material and opening on the front with removable covers to permit of convenient inspection. The boxes will be thoroughly ventilated to allow dissipation of heat. Air will enter through openings in the floor, circulate over the rheostats and then leave the cab through sheet-metal flues extending to the top of the cab and having openings on the side.

AUXILIARY APPARATUS:

The main switches, fuses and air compressor governor will be placed in easily accessible positions on the side of the cab. This apparatus will be suitably mounted and protected with fireproof insulating material so that arcs cannot spread to the metal housing.

The air compressor will be mounted on the floor of the cab and piped to air reservoirs located under the floor of the cab.

THIRD RAIL SHOES:

The third rail shoes will be located at the sides of the locomotive at both ends and will be so spaced as to give considerable distance between them to allow for bridging the third rail at cross-overs and special work.

A shoe fuse will be placed at each shoe where it can be quickly inspected.

OVERHEAD CONTACTS:

The overhead shoes will be placed near the ends of the cab on well insulated platforms. The cables will be led through suitably bushed holes in the roof.

WIRING:

The power and control cables will be run, where practicable, in non-combustible conduits and will be fastened to prevent chafing or loosening by strong cleats of non-combustible insulating material. Every precaution will be taken to guard against short circuits or grounding. In the construction of the cabs, special provision will be made for the wiring so that it may be done in a fireproof and workmanlike manner. Switches and fuses or circuit breakers of ample capacity to open the circuits and give proper protection in case of overloads or short circuits will be inserted as may be necessary in all main circuits.

LIGHTING:

The cab will be well lighted with incandescent lamps. Each headlight will be wired through a separate switch and fuse. Drop lights will be provided to assist in the inspection of apparatus.

PIPING:

All pipes will be of ample size and conform to standard practice. The brake cylinders will be carried on the truck frames. The whistle and bell will be placed on the roof of the cab over the end corridors.

SPECIFICATIONS

FOR

STEEL CABS

GENERAL:

Each style of cab shown is provided with a central corridor running its full length with a door at each end, thus permitting quick communication between locomotives when coupled together.

The general dimensions of the cabs are shown in the detail specifications which follow: Cab "A" to be used with locomotives Nos. 1, 2, 3 and 4, Cab "B" with locomotives Nos. 5 and 6, Cab "C" with locomotive No. 7, and Cab "D" with tender.

The main body of the cabs will be built of sheet steel plates $\frac{1}{8}$ in. thick and mounted upon a platform of structural steel.

PLATFORMS:

Platforms will be constructed of deep side and end channels, with cross beams at intervals, all riveted together into a rigid structure. Gussets, angles and "I" beams will be introduced to provide stiffness and strength.

CAB HOUSING:

The plates will be riveted to steel angles. To stiffen the structure and support the roof and doors, studs and carlines of angle section properly curved to shape will be riveted on. At the ends the plates will be rounded to shape.

Small gutters will be placed over the side doors, side and end windows.

FLOOR:

The flooring will consist of $\frac{3}{16}$ in. steel plates fastened to the platform framing. Trap doors will be formed in the flooring for the inspection of the motors and under parts. Suitable rubber mats to be provided.

DOORS AND WINDOWS:

The frames of the doors and windows will be made of fire-proofed wood. The doors to be paneled with the upper panel of glass and the doors swung on durable hinges. Windows to be arranged for swinging or for sliding sidewise.

BOXES:

The boxes for the contactors and rheostats will be made in two tiers, the rheostats and reversers being placed on the lower tier and the contactors above. This apparatus will be mounted on a strong frame work of structural steel shapes and enclosed in sheet metal boxing with removable doors opening on the front. The boxes to be lined where necessary with fire-proof insulating material and ventilated through openings in the flooring and through broad flues of sheet steel riveted to the cab housing, the flues to open on the outside of the cab just below the roof.

SAND BOXES:

There will be four sheet steel sand boxes, located on each end of the rheostat and contactor boxes. The sand boxes will extend from the floor to the roof, with an opening on the roof, with water-tight covers. With this location the sand will

be kept dry by heat from the rheostats. All apparatus will be securely fastened with bolts and irons of proper shape

MISCELLANEOUS:

On the ends of the platforms will be placed standard signal posts. Grab irons, uncoupling rods and marker brackets will be furnished of standard design and location.

STEEL CAB "A"

DETAIL SPECIFICATIONS

To be used with locomotives No. 1, No. 2, No. 3 and No. 4.

End Windows	
Number	6
Size	4 large $20\frac{3}{8}$ in. x $23\frac{1}{2}$ in. 2 small 10 in. x 29 in.
Movement	Hinged at bottom
Side Windows	
Number	4
Size	31 in. x $24\frac{1}{2}$ in.
Movement	Horizontal slide
Doors	
Number	4
Location	2–end; 2–side
Movement	Hinged
Size of front	$22\frac{1}{2}$ in. x 72 in.
Size of side	$22\frac{1}{2}$ in. x 64 in.
Outline drawing, Locomotive No. 1	T–120476

STEEL CAB "B"

DETAIL SPECIFICATIONS

To be used with locomotives No. 5 and No. 6

End Windows	
Number	4
Size	$20\frac{3}{8}$ in. x $23\frac{1}{2}$ in.
Movement	Hinged at bottom
Side Windows	
Number	8
Size	31 in. x $24\frac{1}{2}$ in.
Movement	Horizontal slide
Doors	
Number	6
Location	End of cab and on middle platform
Movement	Hinged
Size	24 in. x 72 in
Outline drawing	T–120593

STEEL CAB "C"

DETAIL SPECIFICATIONS

To be used with locomotive No. 7.

End Windows	
Number	4
Size	30 in. x 36 in.
Movement	Drop
Side Windows	
Number	8
Size	30 in. x 24 in.
Movement	Slide
Doors	
Number	6
Location	Ends
Movement	Hinged
Size	24 in. x 72 in.
Outline drawing	T–120557

STEEL CAB "D"

DETAIL SPECIFICATIONS

To be used with electric tenders.

End Windows	
Number	4
Size	24 in. x 36 in.
Movement	Vertical slide
Side Windows	
Number	4
Size	30 in. x 36 in.
Movement	Horizontal slide
Doors	
Number	4
Location	2–end, 2–side
Movement end doors	Hinged
Movement side doors	Slide
Size of doors	24 in. x 78 in.
Outline drawing	P–120455
	P–120456

SPECIFICATIONS

FOR

BIPOLAR GEARLESS DIRECT CURRENT MOTORS

MAGNET FRAME

GENERAL:

These motors will have a very few number of parts, being exceedingly simple in construction and arrangement. The four motors will be arranged in tandem and the locomotive truck framing will form part of their magnetic sections.

POLE PIECES:

As shown on the drawings, pole pieces will be cast on the end frames, the double pole pieces between the armatures being carried by bars which act as part of the magnetic circuit, also as cross braces of the truck.

The poles will be shaped so that the armature is free to move between them, with ample clearance on the sides, as the poles move up and down with the riding of the truck on the springs and will be so shaped that the armature will not strike when springs are broken.

FRAME:

To secure sufficient magnetic section, long rectangular bars of steel will be run the entire length of the frame and bolted to the end frames and the cross bars carrying the poles. These bars will be placed in such position that a perfect mechanical balance in the locomotive will be obtained.

FIELD COILS:

The fields will be wound upon metal spools bolted upon the pole pieces. These spools will be thoroughly insulated with mica and wound with flat copper ribbon insulated with asbestos and mica. They will be covered with a special fabric, enclosed in a metal sheathing and treated with a compound which will make them fireproof and impervious to moisture and brake shoe dust. Heat will be effectively radiated and the coils will be well protected from mechanical injury.

CASING:

The motors will be enclosed in a protective guard or casing.

ARMATURE

MOUNTING:

The armatures will be mounted directly on the driving wheel axles and will be centered between the poles by the journal boxes sliding within finished ways in the side frames.

By the removal of the tie bars across the bottom of the frame pedestal jaws, the wheels with the armature may be lowered and removed from the locomotive.

CORE:

The armature core will be of the "Iron clad" type, and will be made up of soft iron laminations accurately punched to size and insulated from each other with coats of japan.

The laminations will be assembled upon a quill and pressed on the axle. The commutator and other parts of the armature will be supported on the quill.

WINDING:

The armature will be of the series drum barrel type. The conductors will be made of high grade copper and specially constructed to prevent undue loss and

heating from eddy currents. The use of connecting leads will be avoided by soldering the conductors directly into the commutator leads. At the back of the armature the top and bottom bars will be connected with thick copper clips riveted and soldered with a high melting point solder. It will be possible to remove the top bars without disturbing the bottom bars.

INSULATION:

The bars will be insulated with wrappings of mica and assembled in sets of five, each set as a whole having an outside covering of mica and specially prepared tape. Long experience with this type of insulation has shown it to be specially well adapted for railway motors, as it may be subjected to high temperatures without material electrical or mechanical deterioration.

BINDING WIRE:

The conductors will be held in place by tinned steel bands imbedded beneath the periphery of the core, the wires being soldered together and held by tinned clips.

The binding wire bands will be designed with ample factors of safety to provide against damage due to operating speed of the locomotives.

COMMUTATOR

SEGMENTS:

The commutator segments will be of hard drawn copper, finished accurately to gauge and insulated throughout with the very best grade of mica.

The commutator ears will be formed integral with the segments, and the segment mica extended up between the ears, thus making a thoroughly insulated, strong and compact construction.

ASSEMBLY:

The segments will be assembled between two strong cast steel commutator shells tightly clamped, the shells being pressed together in a hydraulic press before tightening the retaining bolts.

BRUSH-HOLDERS

INSULATING SUPPORT:

The brush-holders will be made of cast bronze and mounted on suitably insulated supports attached to the frame.

The brush-holders will be made adjustable so as to allow for wear of the commutator and journal bearings. The insulating material used will be of the best quality available.

BRUSHES:

The brushes will be of carbon and will slide freely in finished ways broached in the brush-holders. They will be pressed against the commutator by independent fingers which will give a practically uniform pressure throughout the working range of the brushes. The arrangement of the springs actuating the fingers will be such that there will be but slight pressure on the pins upon which the fingers pivot. This will prevent the finger from sticking on the pins and reduce the wear to a minimum. There will be a "pig tail" or shunt between the fingers and brush-holder body to prevent the current from passing through the springs or pivoting pins. There will be no "pig tail" attached directly to the carbon brushes.

DETAIL SPECIFICATIONS FOR GE-84 RAILWAY MOTOR

FOR LOCOMOTIVES NO. 1 AND NO. 3

Type, Direct Current, Gearless, 600 volts.	
Horse power, 550 on 600 volts, direct current.	
Poles, Number, 2.	
Pole Pieces, Laminated.	
Field Coils, Conductor copper ribbon wound on metal spools.	
Resistance at 75° C.	.0262 ohm.
Section of conductor	4.062 in. x 11 in.
Insulation, mica, asbestos and specially prepared fabric.	
Armature Winding, special series drum type.	
Bars, pressed cable, stranded to reduce eddy currents.	
Insulation, mica.	
Resistance at 75° C.	.0307 ohm.
Section of cable	1 in. x .16 in.
Diameter	29 in.
Length of core	19 in.
Clearance between armature and poles, minimum	.75 in.
Commutator, Diameter	$24\frac{3}{8}$ in.
Length, brush surface	$13\frac{1}{4}$ in.
Depth of segment, front end	$1\frac{1}{8}$ in.
Brushes, number of brush-holders	2
Number of brushes per holder	6
Size of brush	$\frac{7}{8}$ in. x $2\frac{1}{8}$ in.
Drawings, longitudinal section	T–120468
Transverse section	T–120469
Characteristic Curves	C–2967
Approximate weight, armature	6,060 lb.
Armature with wheels and journal boxes (not supported by springs)	12,520 lb.
Rating:	
One hour rating, 600 volts, 75° C. rise	768 amperes.
Continuous rating, 600 volts, 75° C. rise	300 amperes.

DETAIL SPECIFICATIONS FOR GE-94 RAILWAY MOTOR

FOR LOCOMOTIVES NO. 2 AND NO. 4

Type, Direct Current, Gearless, 600 volts.
Horse power, 450 on 600 volts direct current
Poles, number, 2.
Pole Pieces, Laminated.
Field coils, conductor copper ribbon wound on metal spools.

Resistance at 75° C.	.045 ohm.
Section of conductor	4 in. x .080 in.

Insulation, mica, asbestos and specially prepared fabric.
Armature Winding, special series drum type.
Bars, pressed cable, stranded to reduce eddy currents.
Insulation, mica.

Resistance at 75° C.	.050 ohm.
Section of cable	.115 in. x 1.00 in.
Diameter	26 in.
Length of core	22 in.
Clearance between armature and poles, minimum	½ in.
Commutator, diameter	21⅜ in.
Length, brush surface	13 in.
Depth of segment, front end	1⅛ in.
Brushes, number of brush-holders	2
Number of brushes per holder	6
Size of brush	¾ in. x 2 in.
Characteristic Curves	C–2968
Approximate weight, armature	5,310 lb.
Armature, with wheels and journal boxes (not supported by springs)	10,670 lb.

Rating:

One hour rating, 600 volts, 75° C. rise	648 amperes.
Continuous rating, 600 volts, 75° C. rise	240 amperes.

SPECIFICATIONS FOR

FOR

ALTERNATING CURRENT GEARED MOTORS

GENERAL:

In general design the motors will be similar to the G. E. box frame motors. The motors will be of the single-phase compensated type, and will consist of a distributed induction motor winding on a stationary field, connected in series with a multiple wound armature, having a commutator similar in construction to that of the direct current motor.

MAGNET FRAME

CONSTRUCTION OF FRAME:

The main supporting frame will consist of two heavy steel castings between which the laminated magnetic field will be bolted. Caps for the axle bearings will be bolted to vertically planed surfaces on the frame. The armature shaft bearings will be carried in malleable iron heads which will be bolted to bored openings in the frame castings. The armature may be removed endwise through the openings for the bearing heads.

HAND HOLE COVERINGS AND OPENINGS:

A large opening will be provided over the commutator to permit the brush-holders and commutators to be easily reached. This opening will be closed by a malleable iron cover with a felt gasket, and the cover will be held in place by a quickly adjustable cam locking device.

There will also be openings below the commutator and in the sides of the frame at the pinion end. Any or all of the covers bolted over these openings may be left off for ventilation where the service conditions will permit.

OUTLET FOR LEADS:

The armature and field leads will be brought through rubber bushed holes at the commutator end of the motor.

FIELD CORE:

The field core will be built up of soft iron laminations insulated from each other by coats of japan. The teeth of the laminations will be accurately punched and finished by hand after the core is assembled so as to make smooth and uniform slots into which the field coils will be placed.

The punchings will be assembled on keys set in skeleton frames, and will be firmly held when the bolts drawing the two frames together are tightened.

FIELD WINDING:

The field will have a multiple drum winding and will be made up of interchangeably formed coils, thoroughly insulated to withstand a high voltage without injury.

The coils will be assembled in slots and connected together by tinned copper clips soldered with a high-melting-point solder. Joints will be insulated with wrappings of special fabric and tape.

The coils will be held in the slots by wedges and the end windings clamped in place by bronzed rings.

SUSPENSION:

The front side of the motor will be connected to the locomotive framing and supported through a flexible suspension, which will allow an easy lateral movement of the motor. The suspension will be formed of a supporting rod and a spacing sleeve. The rod will prevent the motor from falling and the sleeve will prevent it from rising. The attachment to the motor as well as to the locomotive frame will consist of a ball and socket joint, thus allowing the motor to move freely with the axle.

The motor may be mounted on or removed from the truck from below while the locomotive is over the pit.

BEARINGS

FRAME HEADS:

The frame heads will be made of malleable iron cast in one piece. In order to secure large and long bearings without sacrificing other desirable features of construction the heads, in a cone shape, will be extended well under the commutator shell and pinion end armature core head. This construction will form a very strong and rigid support for the bearing linings.

OIL WELLS:

The frame head castings will have large oil wells into which will be packed oily wool waste, making contact with a large surface of the armature shaft through an opening cut in the low pressure side of the bearing linings.

ARMATURE BEARINGS:

The linings will be made of the best bearing bronze lining with a thin layer of babbitt metal soldered to the interior bearing surface. The babbitt will furnish an ideal bearing surface and will be made sufficiently thin to prevent the armature rubbing against the field in case it is melted out by overheating.

OIL DEFLECTORS:

Waste oil will be prevented from entering the interior of the motor by a series of oil deflectors which will throw it into large grooves cast in the heads, from which it will be conducted away.

ADVANTAGES OF THIS DESIGN:

This form of bearing will be fully equal in simplicity and reliability to the standard car box journal bearing. The method of lubrication and treatment will be practically the same and the box will be reached through large hand holes protected by swing covers held in place by a spring. The amount of oil required for the bearings is exceedingly small.

Records show that these armature shaft bearings have run about 150,000 miles without renewal of the linings. Wide experience indicates that no other type of bearing equal to this has ever been placed on railway motors.

AXLE BEARINGS:

The axle linings will be held in place by cast steel caps tongued and bolted to planed and grooved vertical surfaces on the frame. Large oil wells will be cast in the caps and will be packed with oily waste, bearing against a large surface of the axle through openings cut in the bearing linings. As with the armature shaft bearings, the method of lubrication will be similar to that used for standard car box journals.

ARMATURE

CORE:

The armature core will be of the iron clad type and will be made of soft iron laminations accurately punched to size and insulated from each other with coats of japan. The teeth will be strong and large and not easily displaced with resultant injury to the winding.

WINDING:

The armature winding will be of the multiple drum type. The conductor will consist of copper bars specially constructed to prevent undue loss and heating from eddy currents. The bars will be soldered directly into ears forming an integral part of the commutator segments, thus avoiding entirely the use of connecting leads. At the back of the armature the top and bottom bars will be connected together with thick copper clips, riveted and soldered with high-melting-point solder, but easily taken off in case it is desired to remove the top bars without disturbing the bottom ones. The windings will be especially well protected from carbon dust, oil or mechanical injury. The pinion end core head will extend out under the end windings with a flange extending up past the ends of the coils. The windings at both ends will be covered with a strong canvas dressing securely bound in place.

INSULATION:

The bars will be separately insulated with wrappings of mica and will be assembled in sets of five, each set as a whole having an outside covering of mica protected from mechanical injury by specially prepared tape. Conductors insulated in this way will withstand a high temperature without material injury to the insulation.

BINDING WIRE:

The conductors will be held in the slots by tinned steel wire bands imbedded beneath the periphery of the core, the wires being soldered together and held by tinned clips.

COMMUTATOR

The commutator segments will be made of hard drawn copper finished accurately to gauge and insulated throughout with the best grade of mica. The commutator ears into which the armature conductors are soldered will be formed integral with the segments, and the segment mica will extend up between the ears, thus making a thoroughly strong and compact construction.

ASSEMBLY:

The commutator shells and caps will be made of cast steel, the parts being made especially strong. The segments will be tightly clamped together, the caps being pressed home in a hydraulic press before tightening the commutator bolts.

BRUSH-HOLDERS

MOUNTING:

The brush-holders will be mounted on a revolving yoke which may be rotated on rollers into convenient position for inspection and renewal of brushes. Means will be provided for adjusting position of the yoke and clamping it firmly in place.

The brush-holders will be made of cast bronze, and may be adjusted to allow for the wear of the commutator. They will be supported on mica insulated studs bolted to the yoke.

BRUSHES:

The brushes will slide within finished ways in the holders, and will be pressed against the commutator by independent fingers which will give a firm pressure throughout the working range of the brushes. The arrangement of the springs actuating the fingers will be such that there will be a slight pressure on the pins on which the fingers pivot. This will prevent the fingers from sticking on the pin and thus reduce the wear to a minimum.

There will be a "pig tail" or shunt between the fingers and brush-holder body to prevent current passing through the spring or pivot pin.

GEAR, PINION AND GEAR CASE

GEAR:

The gear will be made of a superior grade of cast steel, and the pinion of forged steel extra hammered to improve the quality of the metal.

PINION:

The pinion will have a taper fit on the armature shaft of $\frac{5}{8}$ in. to the foot, measured radially.

GEAR CASE:

The gear case will be made of malleable iron with a substantial form of support, and will be made especially strong so as to withstand excessive vibration. Both the top and bottom halves of the case will be bolted to the motor frame.

DETAIL SPECIFICATIONS FOR GEA-607 RAILWAY MOTOR

FOR LOCOMOTIVE NO. 5

Type, Alternating Current, Geared, Skeleton Frame.	
Horse Power, 200 on 200 volts alternating current.	
Horse Power, 325 on 300 volts direct current, 2 motors in series.	
Cycles, 25.	
Poles, Number, 8.	
Fields, Laminated.	
Field Coils, distributed winding, interchangeable formed coils.	
Conductor, copper bar.	
Resistance at 75° C.	.0056 ohm.
Size of conductor	.07 in. x .9 in.
Insulation, special fabric and tape varnished and baked.	
Armature Winding, multiple drum type.	
Insulation, mica.	
Resistance at 75° C.	.0048 ohm.
Section of bar	.08 in. x .9 in.
Number of ventilating ducts	2
Diameter	38 in.
Length of core	12.5 in.
Clearance between armature and poles	.150 in.
Commutator, Diameter	32 in.
Length, brush surface	13 in.
Depth of segment, front end	1⅛ in.
Brushes, number of studs	8
Number per holder	6
Size of brush	⅜ in. x 2 in.
Bearings, Armature shaft, pinion end, size	6 in. x 12 in.
Armature shaft, commutator end, size	6 in. x 10 in.
Axle, size	9½ in. x 14 in.
Material in linings, bronze lined with babbitt.	
Lubrication, oil and waste.	
Gear and Pinion, width of face	6½ in.
Diametral pitch	1¾ in.
Ratio of reduction	1.61
Drawings, Outline	T–120478
Characteristic Curves, A. C.	C–2969
Characteristic Curves, D. C.	C–2970
Approximate weights, motor complete, including gear and gear case	15,000 lb.
Armature	5,500 lb.
Rating:	
One hour rating, 200 volts, 75° C. rise	1200 amperes.
Continuous rating, 200 volts, 75° C. rise	650 amperes.

DETAIL SPECIFICATIONS FOR GEA-608 RAILWAY MOTOR

FOR LOCOMOTIVE NO. 6

Type, Alternating Current, Geared, Skeleton Frame.	
Horse power, 250 on 350 volts, alternating current.	
Horse power, 325 on 300 volts direct current, 2 motors in series.	
Cycles, 12.5.	
Poles, Number, 6.	
Fields, Laminated.	
Field Coils, distributed winding, interchangeable formed coils.	
Conductor, copper bar.	
Resistance at 75° C.	.0118 ohm.
Size of conductor	.07 in. x .8 in.
Insulation, special fabric and tape varnished and baked.	
Armature Winding, multiple drum type.	
Insulation, mica.	
Resistance at 75° C.	.009 ohm.
Section of bar	.08 in. x .8 in.
Number of ventilating ducts	2
Diameter	34.5 in.
Length of core	13.5 in.
Clearance between armature and poles	.150 in.
Commutator, Diameter	28 in.
Length, brush surface	11.5 in.
Depth of segment, front end	$1\frac{1}{8}$ in.
Brushes, Number of studs	6
Number per holder	6
Size of brush	$\frac{1}{2}$ in. x $1\frac{3}{4}$ in.
Bearings, Armature shaft, pinion end, size	$5\frac{3}{4}$ in. x 12 in.
Armature shaft, commutator end, size	$5\frac{3}{4}$ in. x 10 in.
Axle, size	9 in. x 14 in.
Material in linings, bronze lined with babbitt.	
Lubrication, oil and waste.	
Gear and pinion, width of face	$6\frac{1}{2}$ in.
Diametral pitch	$1\frac{3}{4}$ in.
Ratio of reduction	1.75
Drawings, Outline	T–120478
Characteristic Curves, A. C.	C–2971
Characteristic Curves, D. C.	C–2972
Approximate weights, motor complete, including gear and gear case	15,000 lb.
Armature	5,000 lb.
Rating:	
One hour rating, 350 volts, 75° C. rise	700 amperes.
Continuous rating, 350 volts, 75° C. rise	340 amperes.

SPECIFICATIONS

FOR

ALTERNATING CURRENT DIRECT CONNECTED MOTORS

GENERAL:

These motors will be of the single-phase compensated type, and so far as their electrical design and construction is concerned will be similar to the geared type of motor described above. Instead of being mounted on the axle, however, each motor will be supported on a steel framework bolted to the truck framing and will deliver power to two of the driving axles through a system of cranks and connecting rods.

The upper part of the motor will project through the floor of the cab allowing easy access to the commutator.

MAGNET FRAME

CONSTRUCTION OF FRAME:

The frame for supporting the field laminations will be of the open type and in general construction similar to the standard General Electric induction motor.

The bearings will be supported by pedestals which will be bolted to the locomotive and field or stator frames. The arrangement of bolts and joints will be such that the frame may be easily removed and the armature taken out for examination or repairs. The end frame will not interfere with the free examination of the air gap.

FIELD CORE:

The field core will be built up of soft iron laminations provided with slots on the inner circumference to receive the windings. The teeth of the laminations will be accurately punched and finished by hand after the core is assembled so as to make smooth and uniform slots for the reception of the field coils. Eddy currents will be prevented by coating the laminations with japan and also by inserting sheets of paper at frequent intervals.

FIELD WINDING:

The field will have a multiple drum winding and will be made up of interchangeably formed coils thoroughly insulated to withstand a high voltage without injury. The coils will be assembled in slots and connected together by tinned copper clips soldered with high-melting-point solder. The joints will be insulated with wrappings of special fabric and tape. The coils will be held in the slots by wedges and the end windings clamped in place by bronze rings.

BEARINGS

The bearings will be self-oiling and will have ample surface to ensure cool running. The oil reservoirs will be capable of holding a liberal supply of oil and convenient gauges for indicating the height of oil and outlets for drawing it off will be provided. The oiling device may be readily examined while the motor is in operation.

ARMATURE, COMMUTATOR AND BRUSH-HOLDERS

The general features and design of the armature, commutator and brush-holders will be as described above for the geared type of motor.

DETAIL SPECIFICATIONS FOR GA-609 RAILWAY MOTORS

FOR LOCOMOTIVE NO. 7

Type, Alternating Current, Direct Coupled, Skeleton Frame.	
Horse power, 700 on 430 volts alternating current.	
Horse power, 750 on 300 volts direct current, 2 motors in series.	
Cycles, 12.5.	
Poles, number, 12.	
Field, laminated.	
Field coils, distributed winding, interchangeable formed coils.	
Conductor, copper bar.	
Resistance at 75° C.	.0066 ohm.
Size of conductor	.075 in. x .875 in.
Insulation, special fabric and tape varnished and baked.	
Armature winding, multiple drum type.	
Insulation, mica.	
Resistance at 75° C.	.0048 ohm.
Section of bar	.06 in. x .875 in.
Number of ventilating ducts	2
Diameter	60 in.
Length of core	14.5 in.
Clearance between armature and poles	.200 in.
Commutator, diameter	55 in.
Length, brush surface	12 in.
Depth of segment, front end	$1\frac{1}{8}$ in.
Brushes, number of studs	12
Number per holder	6
Size of brush	$\frac{1}{2}$ in. x $1\frac{3}{4}$ in.
Bearings, armature shaft, connecting rod end, size	10 in. x 15 in.
Armature shaft, commutator end, size	10 in. x 15 in.
Material in linings, bronze lined with babbitt.	
Lubrication, oil and waste.	
Characteristic curves, A. C.	C–2973
Characteristic curves, D. C.	C–2974
Approximate weights, motor complete	30,000 lb.
Armature	10,000 lb.
Rating:	
One hour rating, 430 volts, 75° C. rise	1700 amperes.
Continuous rating, 430 volts, 75° C. rise	840 amperes.

GENERAL SPECIFICATIONS

FOR

AIR BLAST COMPENSATORS

GENERAL CONSTRUCTION:

Each compensator will consist of a set of flat coils placed vertically and surrounded by a built-up steel core. The compensator will be provided with a substantial iron base, a cast iron cover, and a sheet iron casing. One side of the casing will form a chamber for the supply of air to the compensator and the opposite side will be perforated to allow the escape of the heated air.

Register gates at the top and on one side of the compensator will provide for the control of the air supply to the coils and to the core.

CORE:

The core will be built up of steel laminations of high permeability, and low hysteresis loss. The laminations will also be carefully annealed and insulated from each other to reduce eddy current losses.

AIR CIRCULATION:

The coils will be separated from each other by air spaces, and frequent open spaces or ducts will be provided in the core so that air can be forced through the entire structure to maintain the low temperature necessary to avoid deterioration.

WINDINGS:

The windings will be sub-divided into several coils, each built up of flat conductors wound with but one turn per layer so as to form thin high coils which will present a large radiating surface to the air. The conductors will be cemented together by a special insulating compound, after which exterior wrappings will be applied and separately treated with an insulating varnish, making a very durable and moisture-proof insulation capable of resisting a potential stress much greater than that for which the compensator will be wound.

TERMINALS:

The terminals will be situated in the base of the compensator and openings in the side of the base will give access to them when not readily accessible from the air duct under the compensator.

PERFORMANCE:

After a run of twenty-four hours at rated load, voltage and frequency, the rise in temperature of any part of the compensator, as measured by thermometer, will not exceed 35 degrees Centigrade, and the rise in temperature of the coils, as measured by the increase in resistance, will not exceed 35 degrees, provided the temperature of the surrounding air be not greater than 25 degrees Centigrade and the conditions of ventilation normal. Should the temperature of the surrounding air differ from 25 degrees, the observed rise should be corrected by one half per cent. for each degree.

The compensator will carry an overload of 50 per cent. for 2½ hours without the temperature rise exceeding 55 degrees.

The insulation between the coils and the core will stand a test of 6600 volts alternating current for one minute.

DETAIL SPECIFICATIONS FOR AIR BLAST COMPENSATORS

FOR LOCOMOTIVE NO. 5

Number per locomotive	2
Rated Kw.	330
Cycles per second	25
Primary voltage	3300
Amperes	121
Secondary voltage, maximum	600
Voltage, minimum	300
No. taps	10
Amperes	666
Air required, cubic feet per minute	1200
Pressure, ounce	⅝
Efficiency, 1½ Load	97.6%
Full load	97.5%
¾ Load	97.1%
½ Load	96.2%
¼ Load	93.1%
Height overall	77 in.
Floor space	47 in. x 38 in.
Total weight	8,500 lb.

DETAIL SPECIFICATIONS FOR AIR BLAST COMPENSATORS

FOR LOCOMOTIVE NO. 6

Number per locomotive	2
Rated Kw.	320
Cycles per second	12.5
Primary voltage	3300
Amperes	142
Secondary voltage, maximum	1050
Voltage, minimum	500
No. taps	10
Amperes	445
Air required, cubic feet per minute	1200
Pressure, ounce	$\frac{5}{8}$
Efficiency, $1\frac{1}{2}$ load	97.3%
Full load	97.2%
$\frac{3}{4}$ Load	96.8%
$\frac{1}{2}$ Load	95.7%
$\frac{1}{4}$ Load	92.0%
Height overall	80 in.
Floor space	50 in. x 46 in.
Total weight	10,500 lb.

DETAIL SPECIFICATIONS FOR AIR BLAST COMPENSATORS

FOR LOCOMOTIVE NO. 7

Number per locomotive	2
Rated Kw.	320
Cycles per second	12.5
Primary voltage	3300
Amperes	130
Secondary voltage, maximum	860
Voltage, minimum	430
No taps	10
Amperes	500
Air required, cubic feet per minute	12,000
Pressure, ounce	$\frac{5}{8}$
Efficiency, $1\frac{1}{2}$ load	97.3%
Full load	97.2%
$\frac{3}{4}$ Load	96.8%
$\frac{1}{2}$ Load	95.7%
$\frac{1}{4}$ Load	92.0%
Height overall	80 in.
Floor space	50 in. x 46 in.
Total weight	10,500 lb.

SPECIFICATIONS FOR SPRAGUE-GENERAL ELECTRIC MULTIPLE UNIT CONTROL EQUIPMENT

LOCOMOTIVE NO. 1 WITH FOUR DIRECT CURRENT MOTORS, 600 VOLTS

GENERAL DESCRIPTION

Multiple Unit System The type of motor control herein described is adapted for the control of electric locomotives in a service which requires that they be operated singly, or that several of them be coupled together and operated as a unit. The circuit connections will be so arranged that when a number of locomotives are coupled together the motors on all of the locomotives may be controlled from either end of any locomotive. The locomotives may be coupled in any desired relation and with either end of any locomotive connected to any other locomotive.

Main or Motor Controller The multiple unit system of control may be divided into two parts, the first consisting of a series parallel motor controller composed of a number of electrically operated switches called "contactors," and an electrically operated reverse switch for the motors, called the "reverser." The contactors will make the various electrical combinations of the motors, and regulate the starting resistance in circuit with them.

Master or Secondary Controller The second part will comprise the master controllers, which operate the motor controlling contactors and reversers, relays for automatically checking the acceleration and a multiple cable extending the length of the locomotives and provided with couplers between locomotives.

Automatic Action The control will be semi-automatic in its action, as it will limit the maximum current per motor during acceleration to a predetermined amount (which the motorman cannot exceed), without preventing operation at less than the predetermined current, if desired.

OPERATION

Operation of Contactors All current for the operation of the contactors and reverser of the motor controller will be controlled by the single master controller in use. When the master controller is thrown off, all connections to the operating coils will be cut off and none of the wires in the train control cable will be alive. The supply circuits of the master controllers will be further protected by enclosed fuses.

The various circuits from the master controller and the corresponding train line wires will connect to the contactor coils which will be properly grouped to produce the desired motor connections, and each position of the master controller will correspond to the definite step indicated.

Current Limit Relay The current limiting device will consist of a magnetic relay in series with one motor and controlling a magnetic friction clutch in the master controller. At a predetermined current, for which the relay is adjustable, the armature will make connection for energizing the clutch in the master controller in use. This clutch will lock the cylinder of the master controller so that the operating lever cannot be further advanced by the motorman until the current has fallen sufficiently to permit the relay contact to open.

The motorman in notching up will control the locomotive in exactly the same manner as with the ordinary manually operated master controller, the auto-

matic feature coming into operation only when the rate at which the operating handle is moved would allow more than the desired amount of current to pass through the motors if not limited.

The clutch magnet in the master controller in use will be the only one connected into circuit and a wire in the control cable will make connection between it and all of the current relays on the locomotives. By this connection the operation of the locomotives will be made more uniform, and the slipping of the wheels on one locomotive will not affect the turning on of the master controller as the remaining locomotives will actuate the magnetic clutch and regulate the movement of the controller cylinders.

All current for the operation of the contactors will be controlled by the single master controller in use. A magnetic blow-out will be provided to insure prompt and effective opening of the control circuits.

Reverser Connections

When the master controller is moved to its first forward point, the proper direction wire will be energized and will throw the reverser to its forward position, if it is not already so thrown.

The reverser will be electrically interlocked so that it cannot be thrown when the motors are taking current.

The connections for the operating current will be so arranged that unless the reverser is thrown for the direction of train movement indicated by the master controller handle, the contactors and motors on that particular locomotive will be inoperative.

When the reverser has moved to the proper position, connections will be made by it from the direction wire through the forward reverser operating coil and the coils of the contactors which control the main or trolley leads to the motors.

Running Points

The controller will have three running points; (1) all motors in series; (2) two motors in series and the two groups in parallel; (3) all motors in parallel.

Bridge Connection

The series parallel connection of the motors will be made by the "Bridge" method, in which the connections will be so arranged that the circuit through the motors will not be opened during the transition from series to parallel and substantially the full torque of the motors will be preserved at all times.

Rheostat Connections

The rheostats will be grouped in series and parallel combinations similar to those of the motors, by this means producing the best possible proportioning of resistance sections and at the same time giving uniform distribution of current per contactor.

Control Cut-out Switch

A control cut-out switch will be provided in each locomotive so that in an emergency the operating coils of the contactors, reverser and circuit breaker on a particular locomotive may be disconnected from the control circuit.

Safety Features

It will be necessary to positively energize two distinct train wires in order to operate the contactors required for starting the motors.

Three separate contactors with their main contacts in series will be used for closing and opening each motor circuit.

Several small fuses will be provided in the control circuit for effectively protecting the control apparatus.

Should the train break in two, the control current will be automatically and instantly cut off from the detached rear portion without affecting the ability of the motorman to control the forward part of the coupled locomotives.

PERFORMANCE AND TESTS

Capacity The control apparatus will be of capacity and design suitable for controlling the direction and speed of four 550 H.P. motors per locomotive, and to control three of these locomotives coupled together.

Resistance Steps There will be ten steps in series, seven in series-parallel and seven in parallel connection, and the relative resistance for each step will be such as to secure smooth acceleration on resistance and a smooth transition from series to parallel combination of the motors.

Motor Circuit Fuse The copper ribbon fuse provided for the motor circuit will successfully open any short circuit to which it may be subjected in service.

Control Current The control current will be approximately 10 amperes per locomotive at 600 volts line potential after the coils have reached maximum temperature. To insure prompt action of the reverser, the current for an instant at reversing will be about 16 amperes per locomotive.

Operating Voltage The operating coils of the contactors and reverser will be wound for a working potential of 625 volts without undue heating, and the entire control will successfully operate at a minimum of 300 and a maximum of 750 volts.

Insulation The operating coils will be tested at 5000 volts alternating between winding and shell, and the insulation of the complete apparatus will be tested at 2500 volts alternating. The control system after installation will withstand an insulation test to ground of 2000 volts alternating.

DETAILED DESCRIPTION OF APPARATUS

MASTER CONTROLLER:

The master controller will be similar in appearance to an ordinary street car controller. The operating lever, however, will be about 24 in. long with a horizontal grip portion and will move through an angle of about 90 degrees. A separate lever will be provided for operating the reverse switch.

The controller will be of the drum type and will contain two cylinders connected by gearing to the operating lever. The friction clutch will be geared to these cylinders and will consist of a centrifugal governor with a friction wheel and a magnet coil so placed as to magnetically lock the clutch when the coil is energized.

MOTOR CONTROLLER:

Contactors The contactors will consist of electro-magnet switches controlled by the master controller and will make the various power circuit connections for the control of the motors. Each contactor will consist of a movable arm, carrying a removable copper tip which will make contact with a similar tip, and a coil for actuating the arm, which coil will be supplied with current from the master controller in use. The construction of the arm will be such that a powerful spring action, combined with gravity, will cause the arm to drop and open the power circuit when the master controller circuit is interrupted. The contactor will have an efficient and powerful magnetic blow-out capable of opening the power circuit under conditions far exceeding normal operation.

Reverser The motor circuit connections of the reverser will be similar to those of the ordinary motor reversing switch, but the switch will be actuated by electro-magnets moving it to either forward or reverse position. The operating circuit of the reverser will be arranged to momentarily connect the coils across full potential

to insure movement of the reverser. Contactor coils will be introduced in series with the coil by movement of the reverser, thereby reducing the current and insuring the reverser being held firmly in place.

CURRENT LIMIT RELAY:

This relay will have a heavy sawed copper coil and an iron plunger mounted on a hard bronze stem. The stem will carry a light insulated disk which will make contact with stationary studs when the relay is energized.

The position of the plunger will be adjustable to alter the value of current at which the relay will operate. The contact portions of the disks and studs will be of pure silver.

CONTROL CUT-OUT SWITCH:

This will be a small cylindrical switch provided with contacts corresponding to the contactor circuits and its function will be to cut out the contactors and reverser on any particular locomotive in an emergency. This switch will be mounted on the back of one of the master controllers on a panel which will also form the control connection board for connecting the several circuits of the control cables.

CONTROL FUSES

As an automatic cut-out protection several small enclosed fuses will be connected in circuit between the cut-out switch and the contactors and reversers. These fuses will be contained on the same panel with the control cut-out switch.

MAIN SWITCH FOR MASTER CONTROLLER:

A small enclosed switch and fuse will be provided in the main supply circuit of each master controller.

The switch and fuse will control and protect the entire control system through its particular master controller.

CONTROL COUPLER AND SOCKET:

These will be used for connecting together the control cables on adjacent locomotives and will consist of a socket attached to each car and a removable coupler composed of a suitable length of flexible cable having a plug at each end adapted to fit into the sockets.

The socket will contain twenty separately insulated contacts to which will be connected the wires of the control cable. The insulation in the socket will consist of a molded compound block and it will be firmly held in a substantial iron shell provided with suitable feet for attaching to the locomotive end. The socket will be tapped to take a standard iron conduit for carrying the train line cable entering it.

The coupler socket will be fitted with a spring cover having the dual functions of protecting the interior when not in use and holding in the coupler in service.

The catch on the lid will be designed to hold the coupler in under normal conditions, but will allow it to pull out in case the train breaks in two.

CONTROL CIRCUIT RHEOSTAT:

For the purpose of regulating the operating circuit of the contactors through the several control positions, a special high resistance rheostat is required. The coils of this rheostat will be insulated with mica and mounted in a substantial iron frame.

LIGHTNING ARRESTER:

Two lightning arresters will be furnished, one connected to the main wiring and one to the control wiring, and each having a suitable induction or "kicking" coil between the point of connection and the apparatus it protects.

These arresters will be of the standard type for railway use with short air gap for lightning discharge and magnetic blow-out to rupture line current.

MOTOR CIRCUIT SWITCH:

For the purpose of disconnecting the motors when testing the control or at other times, a quick-break knife blade switch will be provided for opening the main circuit between the line and the contactors.

RHEOSTAT:

The rheostats used in series with the motors in starting will have a resistance composed of cast iron grids mounted together in a frame and insulated with mica. The use of cast iron for the resistance is especially advantageous due to its relatively low temperature coefficient, insuring greater uniformity of control regardless of the temperature of the resistance.

MOTOR CIRCUIT AND SHOE FUSE BOXES:

A separate fuse will be provided for each motor in order to effectively protect the motor and other apparatus.

In addition to these individual fuses a larger one for the shoe circuit will be used.

Each box will be made of pieces of sheet hard fibre, securely fastened together, and will contain terminals placed 8 in. apart. These will be so constructed that the fuse will be securely clamped by wedges which will be drawn into the terminals by screws, the insulated handles of which will extend through the ends of the box so as to be readily manipulated from the outside. The leads to the fuse box will be soldered into taper plugs which will be drawn into the terminals and held by nuts and lock washers.

Magnetic Blow-out

The box will be provided with a very effective magnetic blow-out which will be energized by the current passing through the fuse without any additional coil.

Copper Fuse

The fuse will consist of a thin copper ribbon having a hole in the center to localize the heating. It will have ample capacity for the normal current but will quickly melt and open the circuit when carrying an excessive load.

Owing to its small cross section there will be no large particles of hot copper ejected when the fuse blows, and the magnetic field will bend the two ends of the thin fuse at right angles to their normal position, thereby materially increasing the length of the arc without melting additional metal.

The fuse may be readily placed in position without the use of tools and without opening the box.

MOTOR CUT-OUT SWITCHES:

Cut-out switches of knife blade type will be provided for disconnecting one or more motors from the circuit and permitting the operation of the remaining motors.

The switches will be mounted in pairs (for two motors) on a substantial slate base. Auxiliary contacts for interlocking with the control apparatus will be contained on the same base and operated by the cut-out switches.

THIRD RAIL SHOES:

These shoes will be of the hinged type, and will be designed for use with a protected third rail, either over or under running as desired.

A suitable spring will be provided for producing the requisite pressure between the shoe and rail, thereby eliminating so far as possible any jumping due to irregularity of third rail.

The shoe itself will be made of cast iron, which has proven to be the best metal for the purpose. It will be so designed that should it catch in an obstruction it will break before injuring the support.

The supporting frame will consist of two malleable iron castings with means for obtaining different vertical adjustments in relation to the third rail.

OVERHEAD COLLECTOR:

The overhead collectors will be of the pantograph type arranged to be raised pneumatically and brought to the low position by powerful springs; these operations to be under the control of the engineer by the manipulation of suitable valves in the locomotive cab. The construction proper will consist of a cast steel base thoroughly insulated from the metal portions of the cap, and acting in the dual capacity of a support for the pantograph arms and of a cylinder for the operating piston.

The shoe or contact piece will be gun metal and will be provided with extension horns at either side.

As an auxiliary to the valve controlled by the engineer, an additional valve will be located on the base castings of the trolley and will be operated by a dip in the overhead conductor, located at tunnel entrances, or where desired, and which will automatically cause the shoe to be depressed to its low position, in case the engineer neglects to do so.

POWER FUSE LINE:

This will include the necessary couplers and sockets, connection boxes and protecting fuses.

Coupler The coupler will consist of two plugs each with three contacts in multiple and connected by an extra flexible cable.

The plug will have a malleable iron case with a removable molded insulation block which contains the contact.

The outside of the cable will be clamped in a water tight gasket where it enters the plug casing.

Socket The socket will have a molded insulation body with a back frame of malleable iron tapped to receive iron pipe and provided with feet for bolting to the locomotive end. There will also be a separate front frame attached to the insulation body supporting the spring closed cover. The front frame will thus be thoroughly insulated so as to effectually prevent any short circuit from the contact to the grounded frame.

The coupler will be held in the socket by the cover in a manner similar to the control coupler.

Fuse Box The bus line fuse boxes will be similar to the motor circuit fuse box.

CONTROL CABLE:

Multiple Conductor This is special flexible cable made up of twenty individual insulated conductors. Seventeen conductors of this cable will be used for the control circuits be-

tween couplers, connection boards, master controllers, cut-out switches and contactors. The other conductors will be extra and may be used for air compressor governors or other purposes.

The cable will be made up of twenty DRC cables each composed of 19 strands of No. 25 B. & S. wire with single cotton braid, the complete cable being covered with varnished cambric, and one cotton braid, weather proofed.

Coupler Cable A similar cable, especially insulated with an outside rubber covering, will be used for the connection between the coupler plugs. It will be covered with two braids of cotton with an outside braid of linen, the whole being weather proofed.

Single Conductor Cable Single conductor 19 No. 25 B. & S. DRC cable will be used for control circuit connections to main switch for master controller. This cable will have $\frac{3}{64}$ in. rubber and one cotton braid, weather proofed, and one asbestos braid filled with grey paint.

All cables made of No. 25 B. & S. wire will have a cotton separator between the copper and rubber for preventing the wires from adhering to the rubber, and rendering the cable easier to clean when soldering on terminal.

RHEOSTAT RESISTANCE STEPS:

The values of the starting resistances for the four motors at each point are as follows:

FULL SERIES CONNECTION		SERIES PARALLEL CONNECTION		PARALLEL CONNECTION	
Pt.	Ohms	Pt.	Ohms	Pt.	Ohms
1	1.60	1	.20	1	.10
2	1.20	2	.14	2	.07
3	.80	3	.097	3	.048
4	.40	4	.07	4	.035
5	.28	5	.045	5	.022
6	.195	6	.022	6	.011
7	.14	7	.00	7	.00
8	.09				
9	.044				
10	.00				

LIST OF APPARATUS AND MATERIAL CONSTITUTING CONTROL EQUIPMENT FOR LOCOMOTIVE NO. 1

2—Master controllers.
43—Contactors.
2—Reversers.
1—Current limit relay.
1—Cut-out switch and connection box.
1—Set control fuses.
2—Master controller main switches.
4—Control coupler sockets.
1—Control coupler.
2—Control circuit rheostats.
2—Lightning arresters.
2—Lightning arrester switches.
1—Motor circuit switch.
20—Cast grid rheostats.
4—Motor circuit fuse boxes.
2—Sets motor cut-out switches.
6—Sets shoe fuse boxes.
4—Third rail shoes.
2—Overhead collectors.
4—Bus line coupler sockets.
2—Bus line couplers.
2—Bus line fuse boxes.
1000 ft. single conductor control cable.
150 ft. multiple conductor control cable.

SPECIFICATIONS FOR CONTROL EQUIPMENT FOR LOCOMOTIVE NO. 2 WITH FOUR 600-VOLT DIRECT CURRENT MOTORS

The control equipment for this locomotive will conform to the foregoing specifications for locomotive No. 1, with the following modifications:

PERFORMANCE AND TEST

Capacity The control apparatus will be of capacity and design suitable for controlling the direction and speed of four 450 H.P. motors per locomotive, and will control three of these locomotives coupled together.

Resistance Steps There will be nine steps in series, six in series-parallel and six in parallel connection, and the relative resistance for each step will be such as to insure smooth acceleration on resistance and a smooth transition from series to parallel combination of the motors. The values of the starting resistances at each step will be in the same ratio as given for locomotive No. 1.

LIST OF APPARATUS AND MATERIAL CONSTITUTING CONTROL EQUIPMENT FOR LOCOMOTIVE NO. 2

2—Master controllers.
39—Contactors.
2—Reversers.
1—Current limit relay.
1—Cut-out switch and connection box.
1—Set control fuses.
2—Master controller main switches.
4—Control coupler sockets.
1—Control coupler.
2—Control circuit rheostats.
2—Lightning arresters.
2—Lightning arresters switches.
1—Motor circuit switch.
16—Cast grid rheostats.
4—Motor circuit fuse boxes.
2—Sets motor cut-out switches.
6—Sets shoe fuse boxes.
4—Third rail shoes.
2—Overhead collectors.
4—Bus line coupler sockets.
2—Bus line couplers.
2—Bus line fuse boxes.
1000 ft. single conductor control cable.
150 ft. multiple conductor control cable.

SPECIFICATIONS FOR CONTROL EQUIPMENT FOR 1200 VOLT LOCOMOTIVES NOS. 3 AND 4

The control equipment for these locomotives will conform to the foregoing specifications for the 600 volt locomotives with the following modifications:

GENERAL DESCRIPTION

The general arrangement and connections of the control will be the same as for the 600 volt locomotive except that there will be but two combinations of the motors.

When operating on 1200 volts these will be: (1) all motors in series, and (2) two parallel groups of two motors in series.

When operating on 600 volts the combinations will be: (1) two parallel groups of two motors in series, and (2) all motors in parallel.

A small commutating switch will be provided to change the connections from the master controller so that the same movement of the master controller handle will produce the proper combinations of motors for 1200 and 600 volt running.

RESISTANCE STEPS:

For 1200 volt operation there will be twelve accelerating steps with all motors series and eleven steps with two motors series. For 600 volt operation there will be eleven steps with two motors series and ten steps with all motors parallel. The resistance values will be in the same proportion as given for locomotives Nos. 1 and 2.

OPERATING VOLTAGE:

The operating coils of the contactors will be wound for the same voltage as for the 600 volt locomotives. When operating on 1200 volts a suitable resistance will be inserted in circuit with the control circuits so that the working voltage on the coils will be the same as on 600 volt operation.

INSULATION

Special attention will be given to the insulation of all parts of the control apparatus, which will be made ample for the voltage to which the apparatus will be subjected.

DETAILED DESCRIPTION OF APPARATUS

COMMUTATING SWITCH:

In addition to the apparatus described in the foregoing specifications for the 600 volt locomotives, there will be a commutating switch for changing the connections from the master controller for 1200 volt and 600 volt operation. This will be a small cylinder type switch with two positions arranged to be moved by hand when changing from one voltage supply to the other.

LIST OF MATERIAL:

The list of material for Locomotives Nos. 3 and 4 will be the same as for Locomotives Nos. 1 and 2 respectively with the addition of one commutating switch.

SPECIFICATIONS FOR SPRAGUE-GENERAL ELECTRIC MULTIPLE UNIT CONTROL SYSTEM

LOCOMOTIVES NOS. 5 AND 6, WITH SIX MOTORS FOR ALTERNATING AND DIRECT CURRENT

GENERAL DESCRIPTION

General

This system of control will be essentially similar to the direct current system in that electrically operated switches, or contactors, are used for completing the various motor circuits, and it will also possess the same flexibility of operation, as a number of locomotives may be coupled together in any relation to each other and all controlled from either end of any one of the locomotives.

The control apparatus will consist of a compensator provided with a number of taps to give suitable voltage regulation for alternating current, and of resistances for direct current, with a master controller, located at each end of each locomotive, actuating electrically operated switches or contactors which will be arranged to make the required connections.

The contactors will be connected through a commutating switch in their "A.C." position to the voltage taps from the compensator for alternating current running, and in their "D.C." position to the resistance leads for direct current running.

The commutating switch is to be thrown by hand to its proper position when changing from A.C. to D.C. or vice versa.

For A.C. operation the motors will be connected in two separate groups of three motors in series, and each group of three is operated from one compensator.

For D.C. operation the motors will be operated in series and parallel relation with ten accelerating steps when all motors are connected in series and seven steps when the motors are connected in two groups of three in series with three additional steps for short circuiting one motor in each group. The resistances will be connected in series and parallel and the change from series to parallel connection will be made by the "Bridge" method. The resistance values will be in the same ratio as given for locomotive No. 1.

For direct current operation the contactor operating coils will be supplied with alternating current from a small rotary converter which will be automatically started and cut in to circuit when the commutating switch is thrown to its D.C. position.

Control circuit couplers similar to those for the direct current locomotives will be provided for connecting between locomotives.

PERFORMANCE AND TESTS

Capacity

The control apparatus will be of capacity and design suitable for controlling the direction and speed of six 250 H.P. motors per locomotive and to control three of these locomotives coupled together.

DETAIL DESCRIPTION OF APPARATUS

MASTER CONTROLLER:

The master controller will resemble very closely that used for direct current, as the functions and method of operating are similar.

All current for the operation of the electrically controlled switches, or contactors, will be taken from a low voltage tap on the compensator, or from the rotary converter, and will pass through the master controller in use.

CONTACTOR:

Each contactor will be operated by means of a low voltage shunt coil, and is similar in action to a direct current contactor, except that it will be adapted to alternating current. All iron in the magnetic circuit will be finely laminated, and other precautions are taken to eliminate unnecessary heating. The contacts will be provided with a blow-out magnet.

Electrical interlocking switches will be provided on the direction and series parallel contactors so that only the desired operation can occur.

REVERSER:

The reversers for making proper connections of field leads in changing the direction of movement of the locomotive will be similar in construction and operation to the direct current reversers, except that they will be designed for alternating current operation.

COMPENSATOR:

The compensator will be of the ordinary transformer construction, provided with a simple continuous winding having a suitable number of taps for giving the requisite voltage variations.

COMMUTATING SWITCH:

The commutating switch for changing from A.C. to D.C. operation and vice versa will be a cylindrical switch similar in appearance to an ordinary controller. It will be suitably interlocked with the main switches for A.C. and D.C. current so that the commutating switch must be in its proper position, corresponding with the main switch that is closed, in order to obtain any current on the control system.

ROTARY CONVERTER:

This will be self-contained and automatically started when the switches are in position for direct current operation. It will not be in use when the locomotive is operating on A.C. current.

MISCELLANEOUS:

The various switches, fuses, cables and other details differ from those used on the direct current locomotive only in being adapted to alternating current operation.

LIST OF APPARATUS AND MATERIAL CONSTITUTING CONTROL EQUIPMENT FOR LOCOMOTIVES NOS. 5 AND 6

2—Master controllers.
1—Commutating switch.
29—Contactors.
2—Reversers.
1—Current limit relay.
1—Cut-out switch and connection box.
1—Set control fuses.
2—Master controller main switches.
4—Control coupler sockets.
1—Control coupler.
2—Lightning arresters.
2—Lightning arrester switches.
1—Motor circuit switch.
20—Cast grid rheostats.
2—Sets motor circuit fuse boxes.
2—Motor cut-out switches.
6—Sets shoe fuse boxes.
4—Third rail shoes.
2—Overhead collectors.
4—Bus line coupler sockets.
2—Bus line couplers.
2—Bus line fuse boxes.
1000 ft. single conductor control cable.
150 ft. multiple conductor control cable.
1—Rotary converter for control.

SPECIFICATIONS FOR CONTROL EQUIPMENT FOR LOCOMOTIVE NO. 7

The control equipment for this locomotive will conform to the foregoing specifications for alternating and direct current with the following modifications:

GENERAL:

For both alternating and direct current operation the motors will be connected in series and will have twenty accelerating steps.

CAPACITY:

The control apparatus will be of capacity and design suitable for controlling the direction and speed of two 700 H.P. motors per locomotive and to control three of these locomotives coupled together.

LIST OF MATERIAL:

To be identical with list given for locomotives Nos. 5 and 6.

SPECIFICATIONS FOR SPRAGUE-GENERAL ELECTRIC MULTIPLE UNIT CONTROL EQUIPMENT FOR USE WITH MOTOR-GENERATOR SET CARRIED ON TENDER

GENERAL DESCRIPTION

This control system is intended for use in conjunction with a portion of the control apparatus on the locomotive to be furnished for direct current operation and will therefore, by itself, comprise merely an auxiliary form of control.

The method of control will consist in varying the potential of the direct current taken from the generator carried on the tender.

The generator will be driven by an alternating current motor at a substantially uniform speed. The generator field will be energized by current supplied from a separate exciter mounted on an extension of the shaft, and a series resistance with suitable taps will provide means for varying the field strength. Small contactors on the tender will be used for cutting in and out these field resistance taps step by step as required.

The large contactors on the locomotive will be used for completing the motor circuits and giving the first, or switching point. The reverser on the locomotive will also be used for giving the proper direction of movement.

A separate master controller will be provided which is to be attached to the regular master controller and interlocked therewith for operating the reverser and motor circuit contactors on the locomotive, and generator field contactors on the tender.

A commutating switch will be provided as a part of this auxiliary master controller which will make the proper control circuit connections for direct current operation without tender and for alternating current operation with tender.

This commutating switch will also operate electrically controlled switches on the locomotive for connecting and disconnecting from the main circuit the third rail shoes and the bus line from the motor-generator.

The motors will be permanently connected in parallel when operating from the motor-generator set and the potential may be varied sufficiently to permit a smooth acceleration without the use of series resistance.

In order to ensure promptness in breaking the circuit when cutting off power quickly, three practically simultaneous steps of resistance are introduced in the motor circuit, contactors which are required for straight D. C. operation being used for the purpose.

The bus line coupler and cable on the direct current locomotive will be used for carrying the current from the generator on the tender to the locomotive.

The exciter for the motor-generator field will supply current for the operation of lights, air compressor and control through a separate coupler.

No additional control coupler will be required as the two necessary wires are to be placed in the control coupler used for straight D. C. operation.

This control will be automatic in action, being so arranged that the operator merely moves the master controller handle to either the forward or reverse direction, as desired when accelerating. The small contactors controlling the generator field excitation will be closed automatically in succession, governed by a current limit relay placed in the motor circuit. This arrangement will provide means for keeping the current uniform during acceleration.

PERFORMANCE AND TESTS

The control apparatus will be of capacity and design suitable, when used in conjunction with that required for straight direct current operation, for controlling the direction and speed of four direct current motors on the locomotive with which it will be used. It will also be of sufficient capacity to control three of these locomotives coupled together.

DETAILED DESCRIPTION

MASTER CONTROLLER AND COMMUTATING SWITCH:

The master controller will be very much smaller than the one for straight D. C. operation and will be designed for attaching to it. There will be a single handle for forward and reverse positions, two points being indicated for each. The first will be low speed or switching point on which the complete motor circuit will be established by the main contactors with all motors in parallel without series resistance but with the minimum voltage from motor-generator. The second point will connect in the small contactors for producing the automatic acceleration. If at any time it is desired to arrest the acceleration it will be necessary only to move the operating handle back to the first point.

The commutating switch will be incorporated in the master controller and provided with a separate handle, an interlock being included which will prevent improper manipulation of either of the master controller handles.

CONTACTORS:

The contactors used for varying the field strength of the motor-generator will be similar in appearance and design to the motor circuit contactors on the locomotive, but considerably smaller.

These contactors will be provided with interlocking switches for making suitable control circuit connections for producing automatic operation.

COUPLER FOR EXCITER CIRCUIT:

This coupler is for the purpose of connecting the exciter on the tender to the main cable supplying lights, air compressor and control on the locomotive. It will be quite similar in design but somewhat smaller than the bus line coupler which will be supplied with the direct current locomotives.

ELECTRICALLY OPERATED MAIN CIRCUIT SWITCH:

This switch will be used for transferring the main connections from third rail shoes to motor-generator and exciter circuits.

It will be somewhat similar in design to the reverser, having two positions and two corresponding coils for operating it. As it will be interlocked electrically with the master controllers it cannot be thrown when the motors are taking current.

FIELD RHEOSTAT:

This rheostat will be of standard design suitable for operation in series with the field of the generator.

CURRENT LIMIT RELAY:

This relay will be similar to the relay used on the direct current locomotive.

MISCELLANEOUS:

The various switches, fuses, cables and other details will vary little from those used on the direct current locomotive.

LIST OF APPARATUS AND MATERIAL CONSTITUTING EQUIPMENT FOR AUXILIARY CONTROL FOR USE WITH TENDER

2—Auxiliary master controllers with commutating switches.
1—Set of contactors for varying field strength of generator.
1—Electrically operated main circuit transfer switch.
1—Rheostat for generator field.
8—Coupler sockets for exciter circuit.
1—Coupler for same.
4—Coupler sockets for control.
1—Coupler for same.
4—Coupler sockets for main circuit.
1—Coupler for same.
1—T rheostat for control.
1—Current limit relay.
1—Main switch and fuse for generator on tender.
1—Main switch and fuse for exciter generator.

SPECIFICATIONS

FOR

DIRECT CURRENT MOTOR DRIVEN AIR COMPRESSOR

GENERAL:

This compressor will be of the direct coupled type and has been designed especially for use with heavy electric locomotives.

The set will consist of a duplex single acting vertical air compressor, mounted on common base, and direct connected to two eight-pole series wound direct current motors. The compressor will be mounted between the motors, and the arrangement will be such that the combined construction will form a compact, simple, self-contained and easily accessible mechanism. The motors will be bolted one to each end of the compressor frame. While economical in space occupied, the parts have been so liberally proportioned that although intended to be operated intermittently, the set will not be injured by continuous operation.

MOTOR FRAMES:

The motor frames will be of cast steel of high permeability. The side of each frame next to the compressor will form a shield of conical shape carried well under the armature so as to utilize all available space for the accommodation of a long bearing and a large oil pocket. This end of the frame will also be provided with a cylindrical flange, the surface of which will be accurately turned so as to center the motor in the compressor frame, to which it will be bolted.

The outside end of the frame will have a narrow inwardly projecting flange which will support the brush-holders and to which a perforated end cover will be attached. This cover is intended to prevent dangerous contact with the rotating parts, and the perforations will be sufficiently large to permit inspection and adjustment of the brushes.

The poles and pole pieces will be made of soft iron laminations riveted together and bolted to a finished surface on the magnet frame. The field coils will be wound and insulated in accordance with General Electric standard practice for railway motors.

COMPRESSOR FRAME:

The compressor frame, primarily the crank chamber, will form a pedestal for the support of the compressor and motors, having lugs at the base for bolting to the floor of the locomotive cab. The top of the frame will be finished to receive the base of the twin cylinders and the sides faced and bored to center and support the motors. At each side of the crank chamber will be a large round opening with an air tight door, which may be easily removed for the inspection of cranks and bearings.

CYLINDERS AND VALVES:

The two cylinders will be cast in a single piece and will be well ribbed to radiate the heat of compression. They will be accurately centered and securely bolted to the top of the compressor frame, and will be supplied with independent sets of intake and exhaust valves of the tubular type which will work in a vertical position on the top of the cylinders. All air passages will be liberal and the intake will be protected from dust by a hollow screen.

SHAFT AND BEARINGS:

The shaft will be turned from a steel forging. Each end will be tapered for the reception of the armature spider, and will be provided with a key and clamping nut for rigidly holding the armature. The middle portion of the shaft will consist of two cranks, 180 degrees apart.

CONNECTING RODS AND PISTONS:

The connecting rod will be of malleable iron of an "I" section, so as to secure rigidity with lightness. The wrists will be lined with bronze and will swing on large hollow steel pins securely fastened in the pistons. The bearing linings of the cranks will be of split bronze held in place by caps bolted to the lower ends of the connecting rods. Attached to these caps will be provided an oiling device which will take oil from the crank chamber and force it up to the wrist pins.

ARMATURES:

The armature coils will be wound on forms and will be securely insulated with fabric of high insulating and durable qualities. The commutator segments will be of the best hard drawn copper insulated with mica and firmly clamped together. The armature cores will consist of soft iron laminations securely clamped together and keyed to the armature spider. The hoods of the spider will be tapered, bored and reamed so as to accurately center on the shaft.

BRUSH-HOLDERS:

There will be four brush-holders for each motor, each supported from the frame and well insulated therefrom. They will be adjustable to the wear of the commutator.

DETAIL SPECIFICATIONS FOR CP-19-B DIRECT CURRENT MOTOR DRIVEN AIR COMPRESSOR

Piston displacement, 75 cu. ft. of free air per minute.	
Revolutions per minute at 130 lb. tank pressure	172
Number of single acting pistons	2
Stroke	8 in.
Diameter of piston	7¾ in.
Amperes input at 130 lb. pressure, 600 volts	26
Main bearings, number	2
Diameter	4 in.
Length	8⅞ in.
Crank bearings, diameter	3.5 in.
Length	4 $\frac{7}{16}$ in.
Wrist pin bearing, diameter	2.5 in.
Length	4.5 in.
Height overall	4 ft. 1⅛ in.
Width overall	2 ft. 7⅛ in.
Length overall	4 ft. 3⅛ in.
Discharge passage, iron pipe, diameter	2 in.
Weight of set, complete	3600 lb.
Drawings, outline	T–120444
Section	T–120345

SPECIFICATIONS

FOR

ALTERNATING CURRENT MOTOR DRIVEN AIR COMPRESSOR

GENERAL:

This compressor may be operated either on single-phase alternating current or direct current, and will consist of a duplex single acting vertical air pump located above and geared to an electric motor through herring-bone gears.

MOTOR FRAME:

The magnet frame for this motor will be rectangular in shape. The magnetic circuit will consist of soft iron laminations slotted to receive the field winding and bolted to the end castings and to the underside of the compressor frame in such manner as to permit removal without interference with the compressor.

COMPRESSOR FRAME:

The compressor frame will have a rectangular base and will carry the weight of both compressor and motor, the cylinders being bolted to the top and the underside finished to receive the motor frame. The sides of the frame will be of a shape suitable to carry the bearings and will be provided at the base with lugs for bolting to the floor of the locomotive. An oil tight door will be placed on each side of the frame for inspection of the connecting rods and bearings.

GEARING AND GEAR CASE:

The gearing will consist of gear and pinion having accurately cut herring-bone teeth. The gear case will be split vertically, the two parts being bolted together and supported on the compressor frame. The gears will be supplied with lubrication from an oil basin beneath the pinion, and the whole will be made oil tight.

CYLINDERS, ARMATURE, ETC.:

The cylinders, valves, shaft, bearings, connecting rod, armature and brush rigging will be of general construction substantially as described for the direct current compressor.

DETAIL SPECIFICATIONS FOR CPA-53 ALTERNATING CURRENT MOTOR DRIVEN AIR COMPRESSOR

Piston displacement, 75 cu. ft. of free air per minute.

Revolutions per minute at 130 lb. tank pressure	172
No. of single acting pistons	2
Stroke	8 in.
Diameter of piston	$7\frac{3}{4}$ in.
Revolutions of motor, per minute	1200
Volt-amperes input	15600
Motor bearing, commutator end, diameter	$2\frac{1}{2}$ in.
Length	$6\frac{5}{8}$ in.
Motor bearing, gear end, diameter	$2\frac{3}{4}$ in.
Length	7 in.
Compressor main bearings, number	2
Diameter	4 in.
Length	$8\frac{7}{8}$ in.
Crank bearings, diameter	3.5 in.
Length	$4\frac{7}{16}$ in.
Wrist pin bearing, diameter	2.5 in.
Length	4.5 in.
Height overall	5 ft. 0 in.
Width overall	2 ft. 10 in.
Length overall	3 ft. 7 in.
Discharge passage, iron pipe, diameter	2 in.
Weight of set, complete	3600 lb.

SPECIFICATIONS

FOR

AIR COMPRESSOR GOVERNOR

CONSTRUCTION:

The governor will consist of a piston acted upon on one side by a diaphragm subjected to reservoir pressure and on the other side by an adjustable regulating spring. The movement of this piston will actuate the operating levers, one of which will carry the contact fingers by means of which the circuit will be made and broken. The construction of these levers will be such that the contacts will be held under pressure, and the pressure will be maintained at a constant maximum value, until at the instant of breaking the circuit, when the contacts will be separated with a quick snap action.

MAGNETIC BLOW-OUT:

The construction of the contacts and arc chutes will be similar to that of the Sprague-General Electric Train Control Contactors, a powerful magnetic blow-out being provided to disrupt the arc when the circuit is opened.

REGULATION:

Adjusting screws will be provided to regulate the governor for any pressure within the range of the spring used. The difference between the opening and closing pressures (one hundred and thirty-five (135) pounds to one hundred and twenty-five (125) pounds) may be slightly varied, the usual practice of allowing ten (10) pounds difference being thus followed. A reduction in air pressure actuating any governor will simultaneously start up all other air compressors connected in the train system; and likewise, when the air pressure has been raised, and any one air compressor is closed down, all others will be cut out of service. The parts will be made of sufficient size to insure great durability and long life. The current carrying parts will be designed to enable the governor to carry its full load continuously.

SPECIFICATIONS

FOR

FLASH BOILER HEATING PLANT

GENERAL:

The heating system described herewith will be installed in the center of the locomotive cab and will be designed for supplying steam to the heating systems of passenger trains having standard steam heating equipments as supplied from boilers of steam locomotives. The plant will consist of a boiler, burners, starting atomizers, electric motor driven water and oil pumps, water tank, oil tank, pressure regulator and necessary piping, indicating gauges and reducing valve for connecting between the flash boiler and train steam pipe.

A boiler may supply steam to a train singly or may be operated in parallel with the boilers of other locomotives to which it may be connected.

OPERATION

The plant will be automatic in regulation, maintaining the steam pressure from no output up to full output of the boiler. There will be no smoke emitted from the stack either when running or starting, and the burners may be started without difficulty when the locomotive is in motion. The boilers are started in the following manner:

1st. The oil trays of the atomizers will be filled with kerosene.

2nd. When ready to start the wicks in the oil trays will be lighted.

3rd. Air pressure of about 20 lb. will be applied to the atomizers and they will be allowed to heat the main burner vaporizers and nozzle for not less than three minutes.

4th. The valve connecting the pressure tank to the main boilers will be open, supplying oil at about 5 lb. pressure. The plant will be allowed to operate in this manner for two minutes.

5th. The pumps will then be started and the valve from the oil pressure tank closed. The plant will then be under way.

6th. The air valve to the atomizer will then be turned off.

The usual time required to bring the boiler up to its full generating capacity, starting cold, is 6 to 7 minutes.

CAPACITY

The heating plant will have an evaporating capacity sufficient to generate 1000 lb. of saturated steam per hour at approximately 100 lb. gauge pressure.

Each heater is designed to run in two independent sections so that at light load the efficiency may be increased by the use of only half the plant. The capacity of the water tank will be 2500 lb. and of the oil tank 60 gallons, these capacities being sufficient to operate the boiler at its maximum output continuously for two hours. On the basis of 80 lb. of steam per car per hour at 5 lb. pressure, a 15 car train may be supplied with heat for four hours, the two boilers of the double locomotive being connected in parallel for this purpose.

DETAILS OF EQUIPMENT

BOILERS:

The boiler will consist of a nest of steel tubing containing water and generated steam, and a suitable burner compartment for the burners, atomizers, etc.

The boiler will be rectangular in shape, the heating tubes and fire chamber being contained in a box of sheet steel with a non-conducting lining. The stack will rise from the center of the boiler and pass through a hole in the roof of the locomotive which will be covered by a hood for shedding the water, all being supported by a suitable steel frame work. The general arrangement is shown on photograph 202,925.

FRAME:

The frame will be of cast steel and will be provided with legs to bolt to the locomotive frame, ways upon which the journal plates rest and lugs for connecting to the braces which hold the boiler in place.

STACK:

A sheet iron stack made of two concentric pipes will pass from the center of the boiler through the roof, as described above.

TUBING:

The boiler tubing will consist of a set of ½ in. steel grids electrically welded together to form a continuous pipe. The construction is shown on photograph 0757. The boiler will be made in two sections supported by a non-conducting partition so that either section may be operated independently of the other.

BURNERS:

The general design of the burner is shown on photograph 0750.

ATOMIZERS:

These devices, used for quick starting of the burners, will consist of a cast iron oil tray of a capacity sufficient to operate the boiler for about six minutes. The air for atomizing is carried through a steel forging passing through the oil tray and forming a nozzle for both air and oil.

Asbestos wicks will be placed in the oil tray immediately in front of the atomizer nozzles and will be lighted when the atomizers are started, serving then to prevent the atomizers from being accidentally extinguished. A steel plate fastened in front of the nozzle will divide the flame in such manner that one portion of the flame will heat the burner nozzle and the other portion the top of the main reservoir vaporizers.

PUMPS

The oil and water pumps will be mounted on a common bed-plate and will be driven through a worm gear by a 1 H.P. 600 volt compound wound direct current motor for D.C., and single-phase motor for A.C. Each pump will consist of two single acting elements which may be operated in independent pairs.

The ratios of the plunger displacement will be approximately the same as the ratio between oil and water required. If it is desired to change the quality of the steam, an additional adjustment may be obtained by changing the stroke of the oil pump.

REGULATOR:

The motor driving the pumps will be controlled by a standard MB Form C air compressor governor which will close and open the motor circuit through a pressure range of 10 lb. This regulator is shown on photograph 300,750.

TANKS

The water tank will be made of galvanized sheet steel and will have a capacity of 2500 lb. (300 gallons).

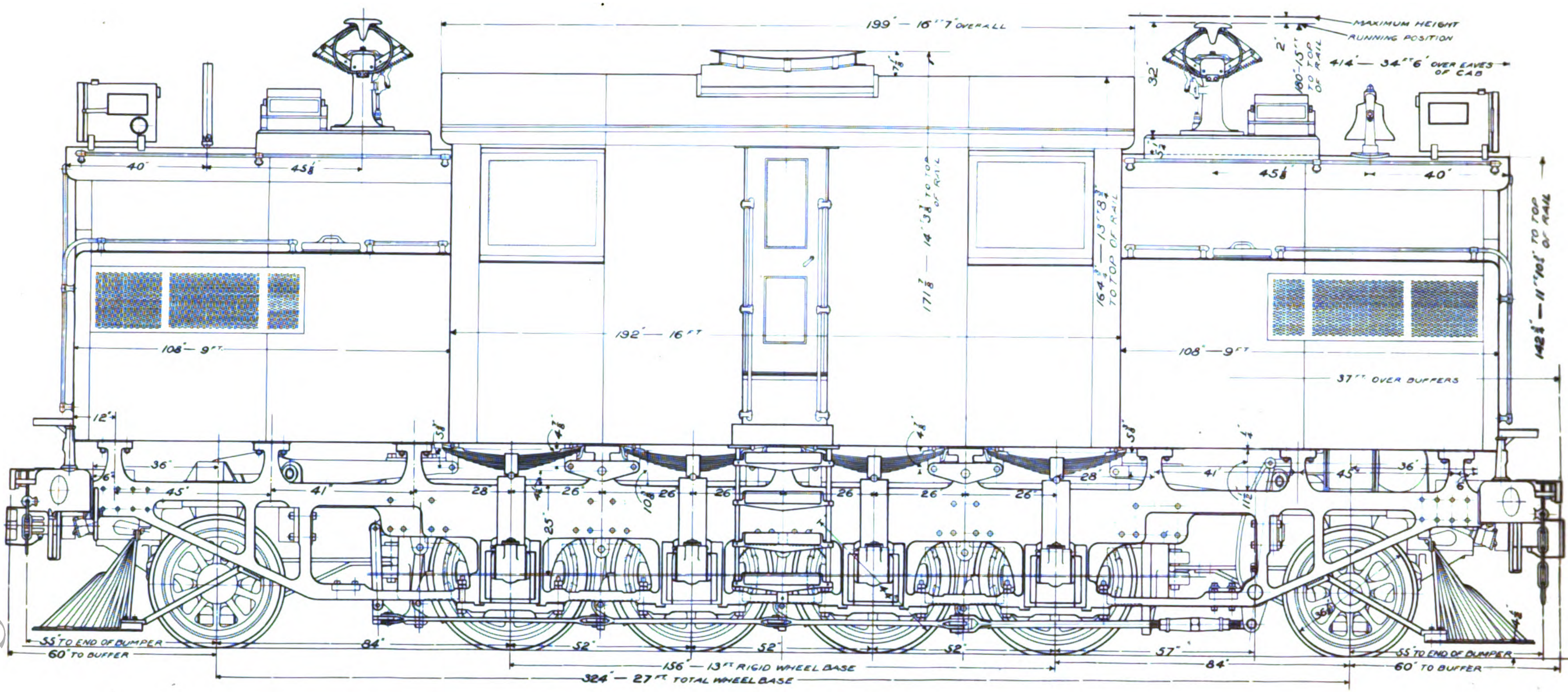
The main oil tank will also be of galvanized sheet steel and will have a capacity of 60 gallons. The pressure tank will be cylindrical in form, capacity 8 gallons.

PIPING, GAUGES, ETC.

The plant will be equipped with all necessary piping for water and oil connections and for steam connections from the boiler to the train steam pipe. Suitable gauges will be furnished for indicating oil pressure in the burners, air pressure on the atomizers, air pressure on the oil pressure tanks, and steam pressure in the main steam pipe. A standard reducing valve will be furnished for regulating the steam pressure in the train steam pipe.

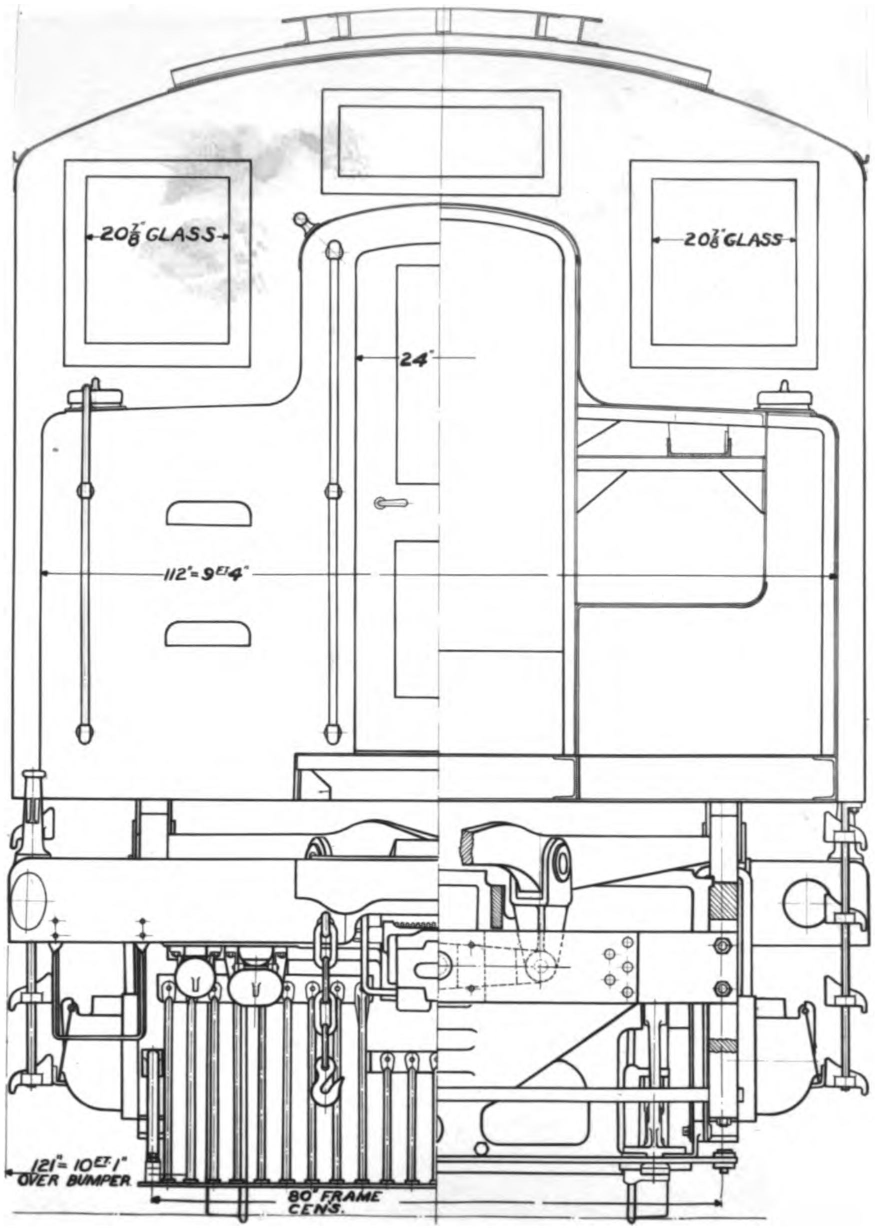
APPROXIMATE DIMENSIONS

Boiler frame, floor space	4 ft. 6 in. by 2 ft. 4 in.
Height	3 ft. 5 in.
Water tank, floor space	3 ft. 6 in. by 2 ft. 6 in.
Height	5 ft. 0 in.
Oil tank, floor space	36 in. by 10 in.
Height	2 ft. 10.5 in.
Pumping set, floor space	3 ft. 2 in. by 1 ft. 7 in.
Height	1 ft. 4 in.
Total weight of plant exclusive of oil and water approximate	2800 lb.



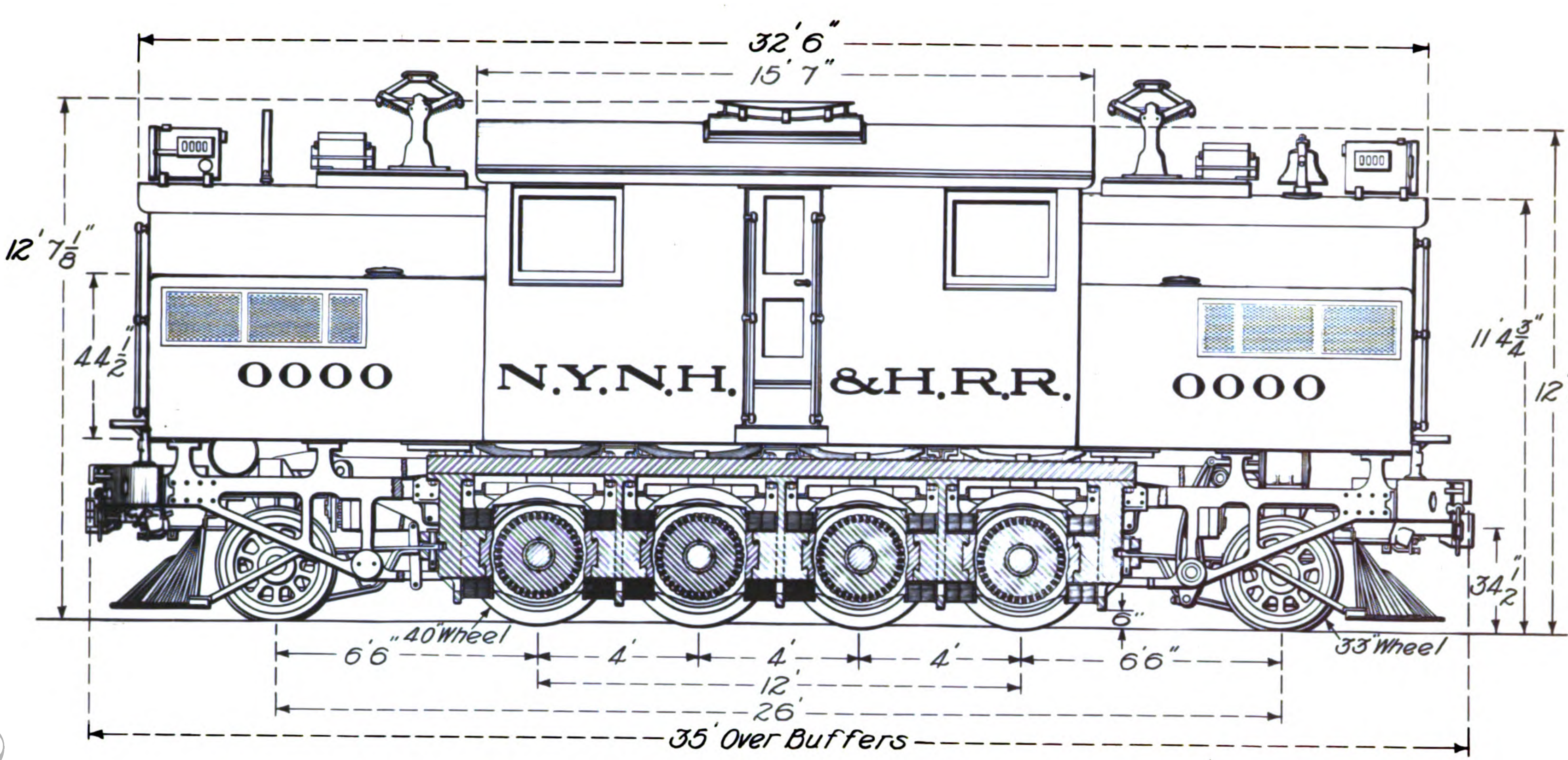
SUBJECT TO CHANGE. NOT FOR CONSTRUCTION UNLESS SPECIALLY APPROVED

202955 LOCOMOTIVE NO.1 EQUIPPED WITH 4 GE-84 MOTORS.
OUTLINE.

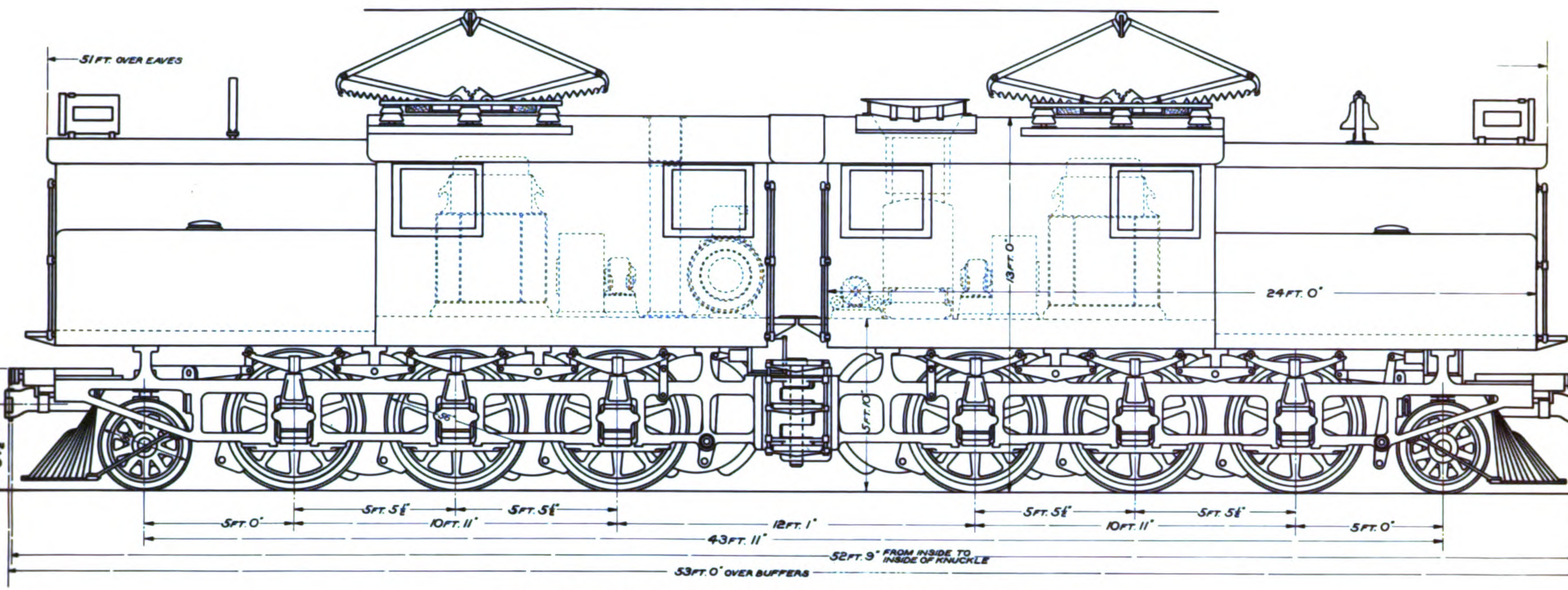


SUBJECT TO CHANGE. NOT FOR CONSTRUCTION UNLESS SPECIALLY APPROVED

202956 LOCOMOTIVE NO.1, EQUIPPED WITH 4 GE-84 MOTORS.
END ELEVATION.

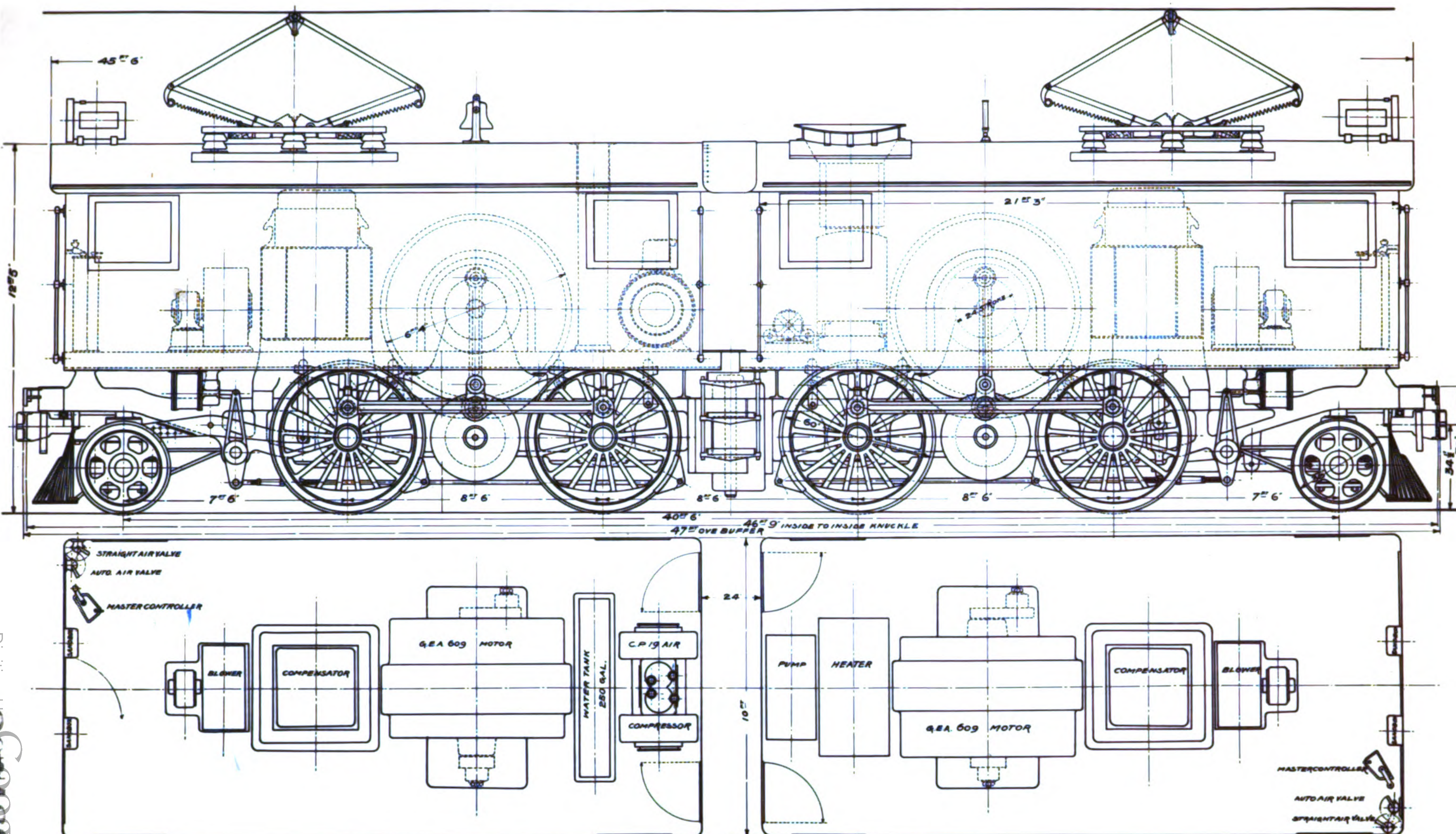


202948 LOCOMOTIVE NO.2 - OUTLINE AND LONGITUDINAL SECTION THROUGH FRAME.



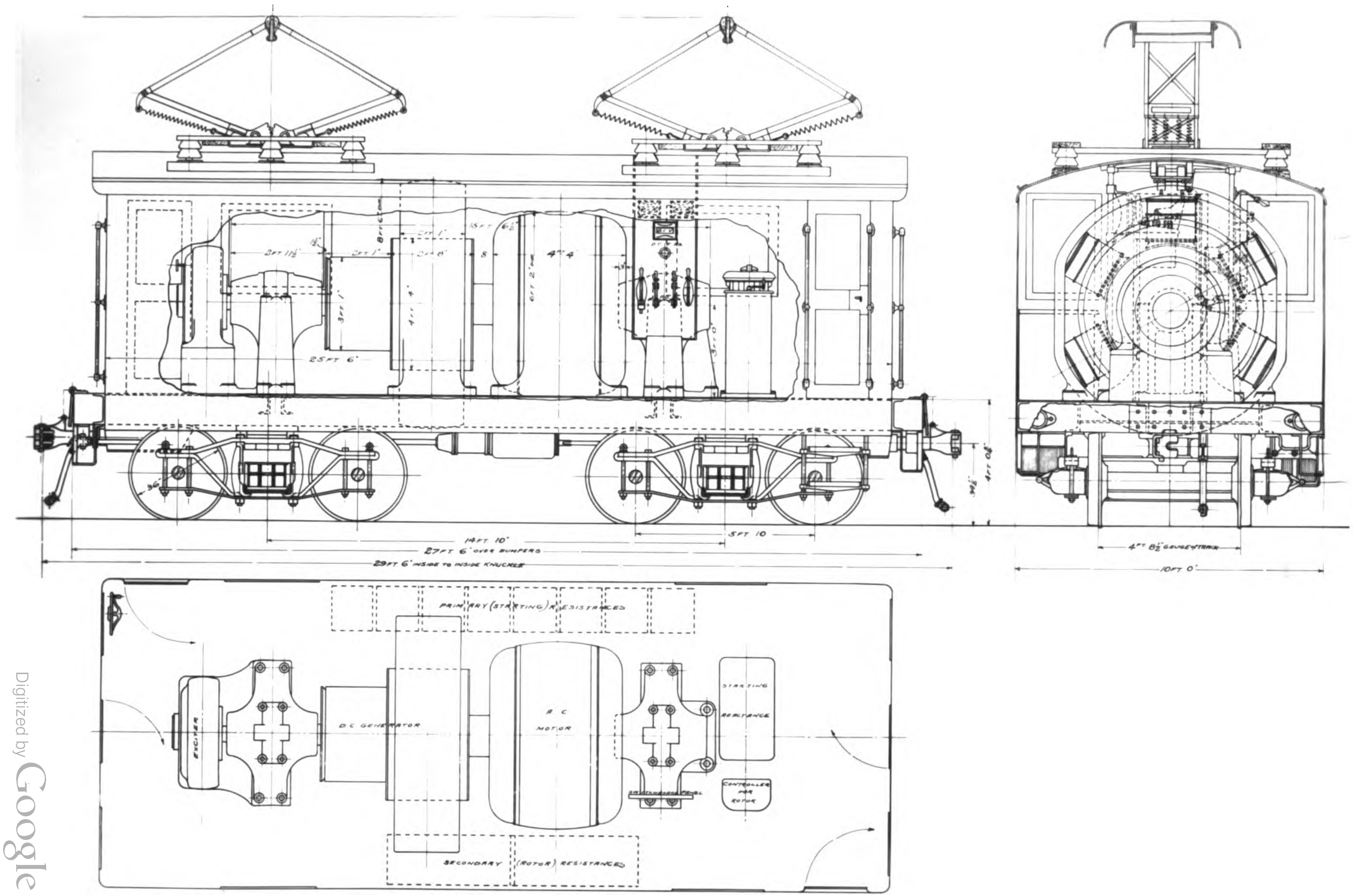
SUBJECT TO CHANGE. NOT FOR CONSTRUCTION UNLESS SPECIALLY APPROVED

202966 LOCOMOTIVE NO.5 AND 6 EQUIPPED WITH 6- 200 H.P.
ALTERNATING CURRENT MOTORS.
OUTLINE.



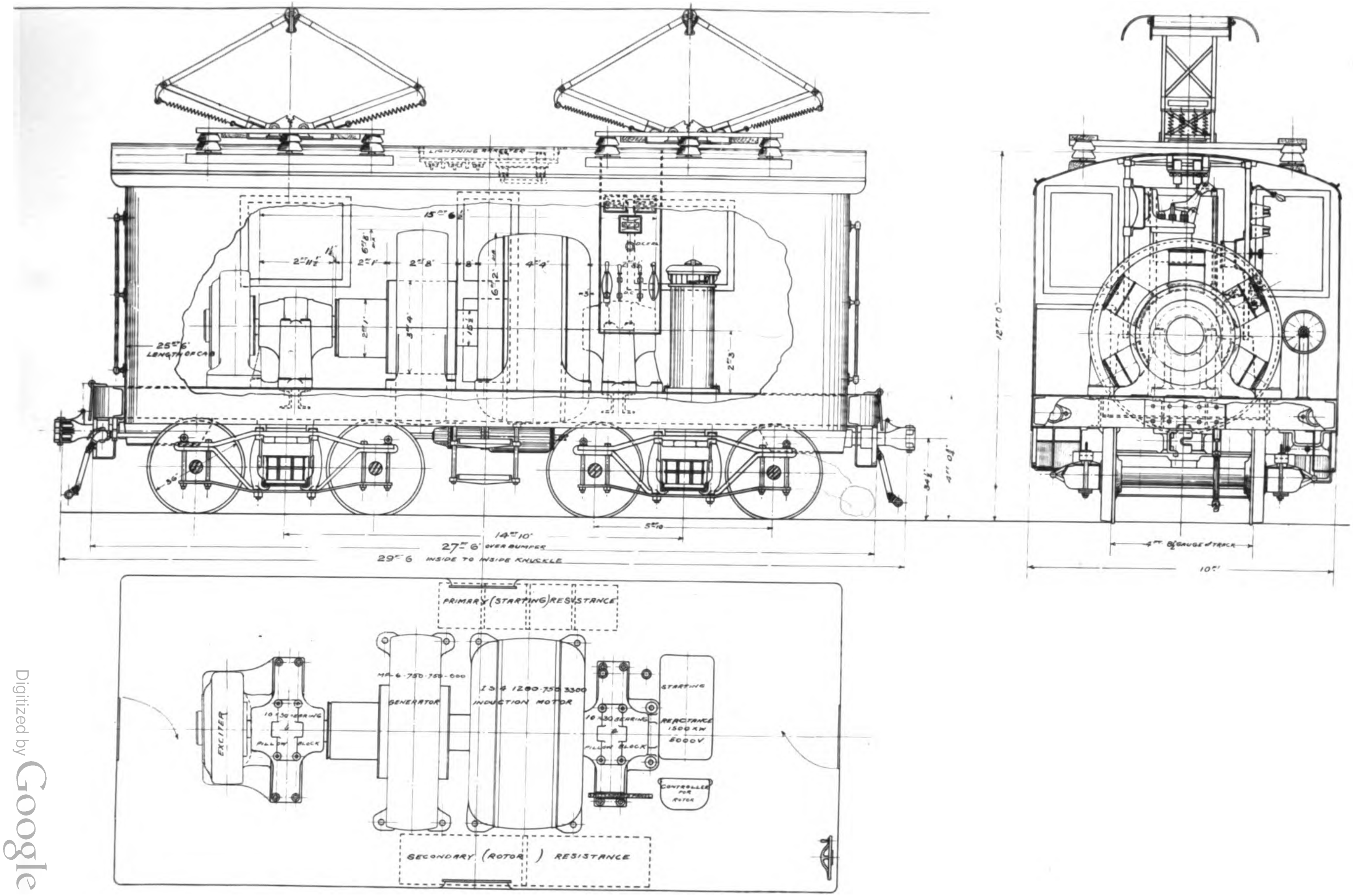
SUBJECT TO CHANGE. NOT FOR CONSTRUCTION UNLESS SPECIALLY APPROVED

202967 LOCOMOTIVE NO.7 EQUIPPED WITH 2- GEA-609 ALTERNATING CURRENT RAILWAY MOTORS. OUTLINE.



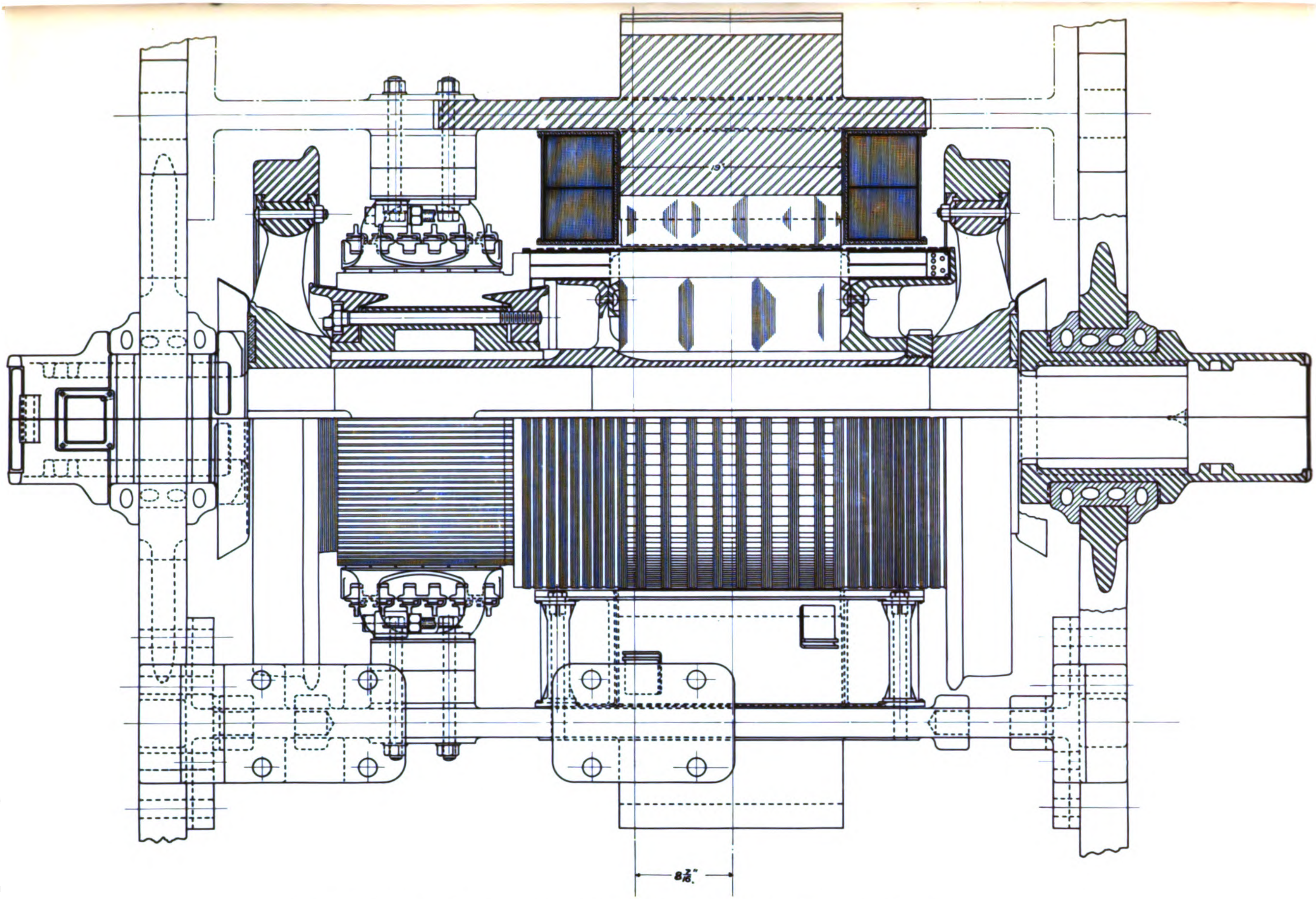
SUBJECT TO CHANGE. NOT FOR CONSTRUCTION UNLESS SPECIALLY APPROVED

202969 900 K.W. MOTOR GENERATOR TENDER FOR LOCOMOTIVE NO.1.
OUTLINE.



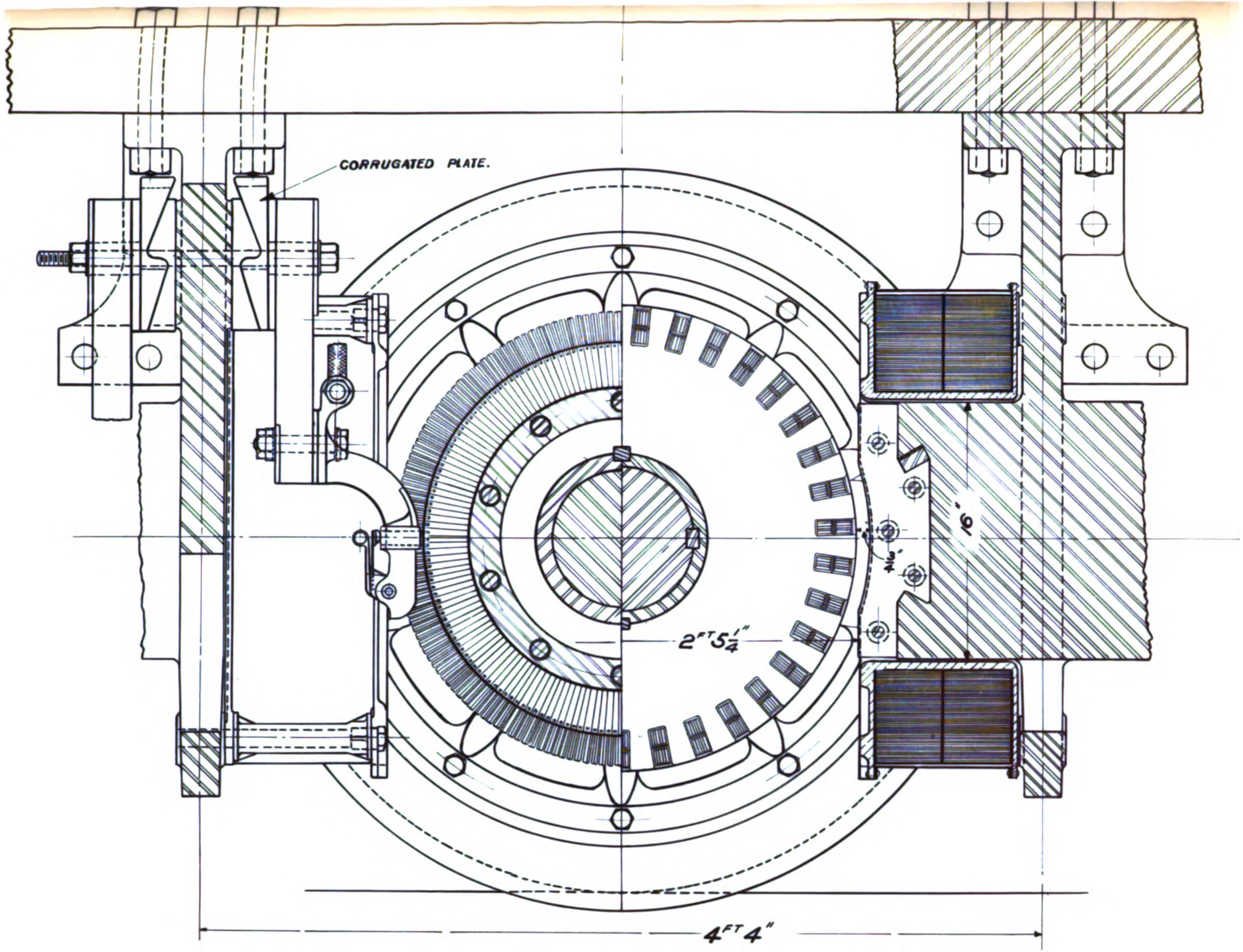
SUBJECT TO CHANGE. NOT FOR CONSTRUCTION UNLESS SPECIALLY APPROVED

202968 650 K.W. MOTOR GENERATOR TENDER FOR LOCOMOTIVE NO.2.
OUTLINE.



SUBJECT TO CHANGE. NOT FOR CONSTRUCTION UNLESS SPECIALLY APPROVED

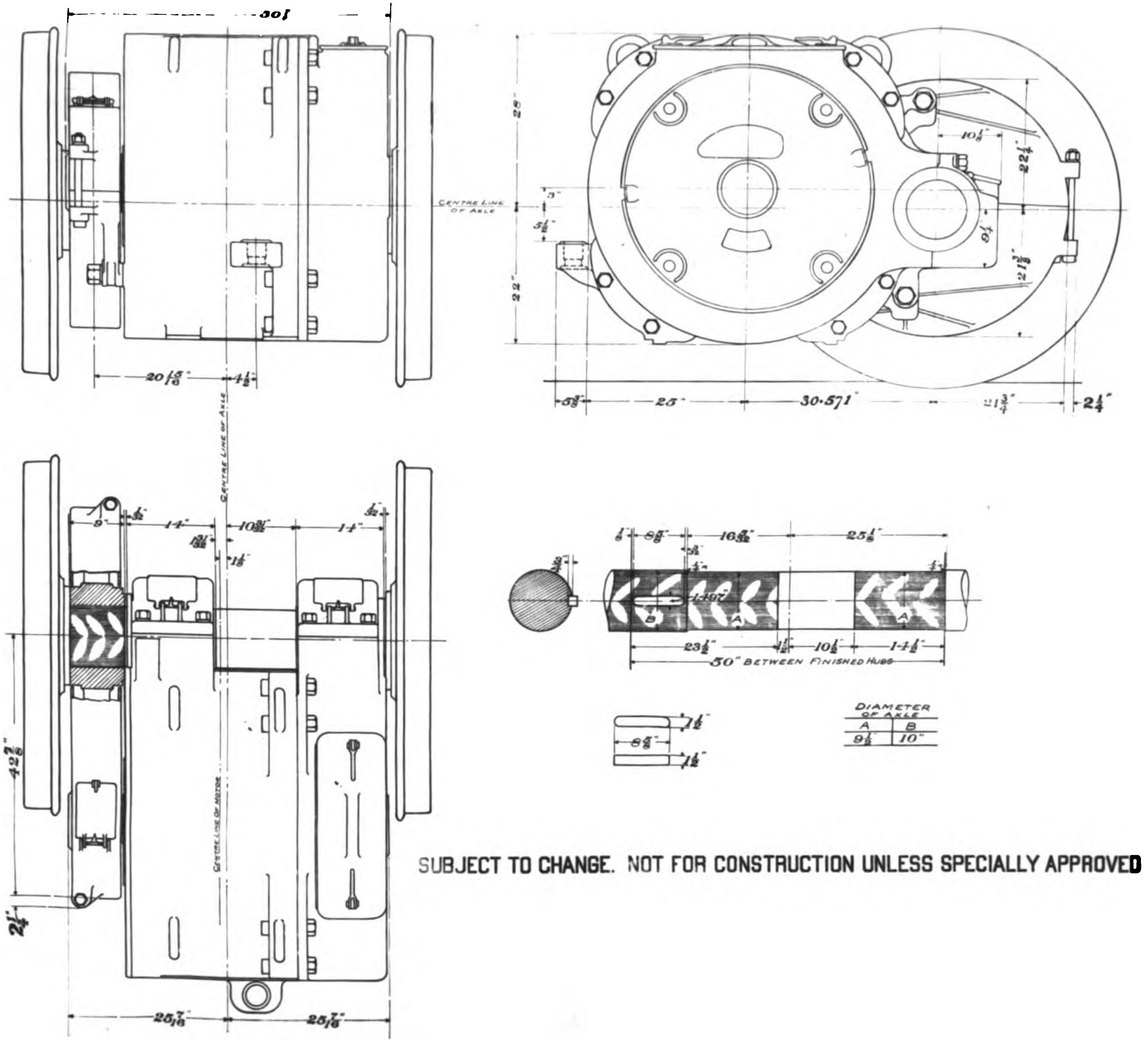
202945 GE-84-BIPOLAR GEARLESS DIRECT CURRENT MOTOR.
LONGITUDINAL SECTION.



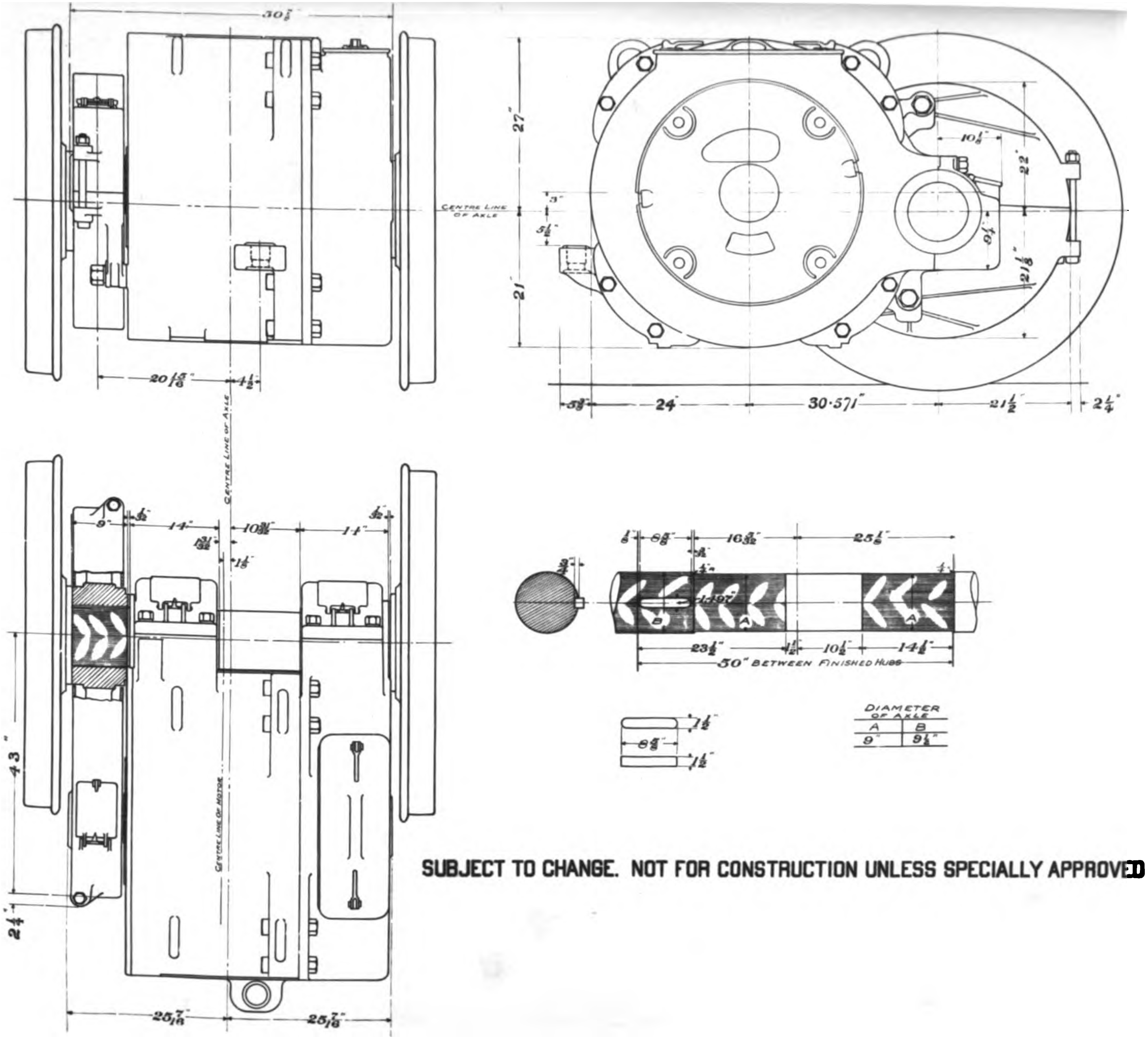
SUBJECT TO CHANGE. NOT FOR CONSTRUCTION UNLESS SPECIALLY APPROVED

202957 GE-84 BIPOLAR GEARLESS DIRECT CURRENT MOTOR.
TRANSVERSE SECTION.

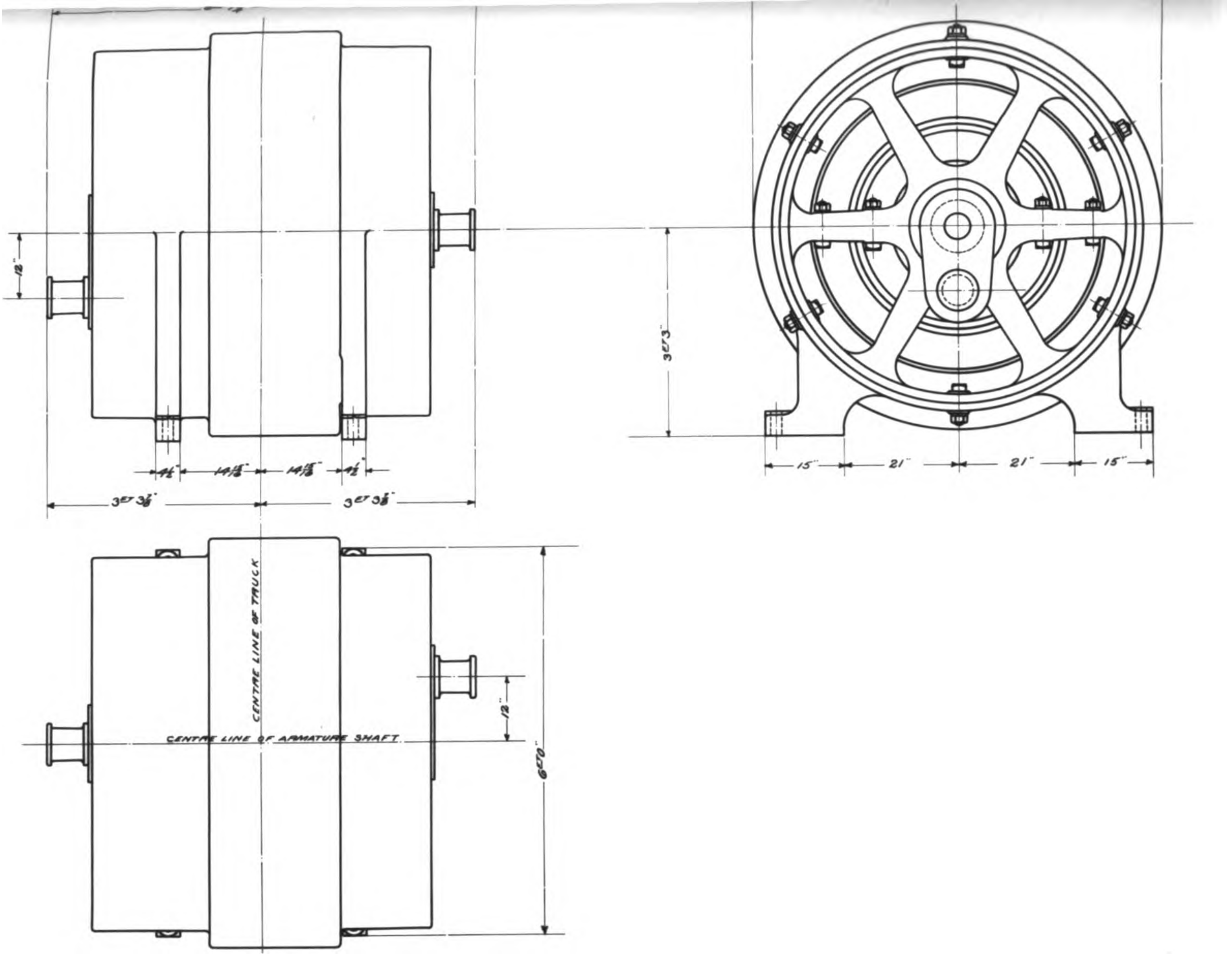
202129 ARMATURE, AXLE AND WHEELS FOR MOTORS ON ELECTRIC LOCOMOTIVE FOR N.Y.C. R.R. CO.



202939 GEA-607-A ALTERNATING CURRENT RAILWAY MOTOR.
OUTLINE.

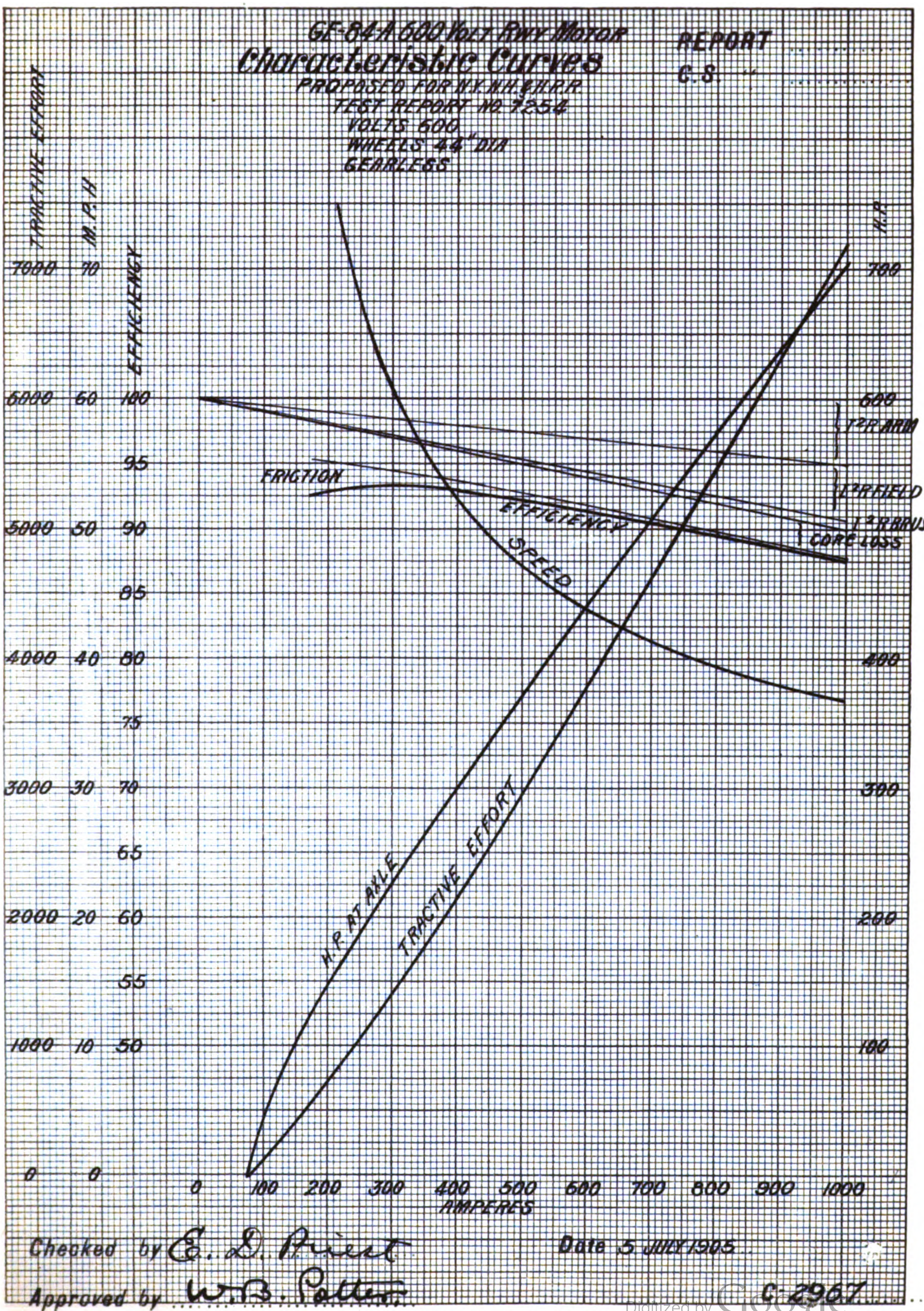


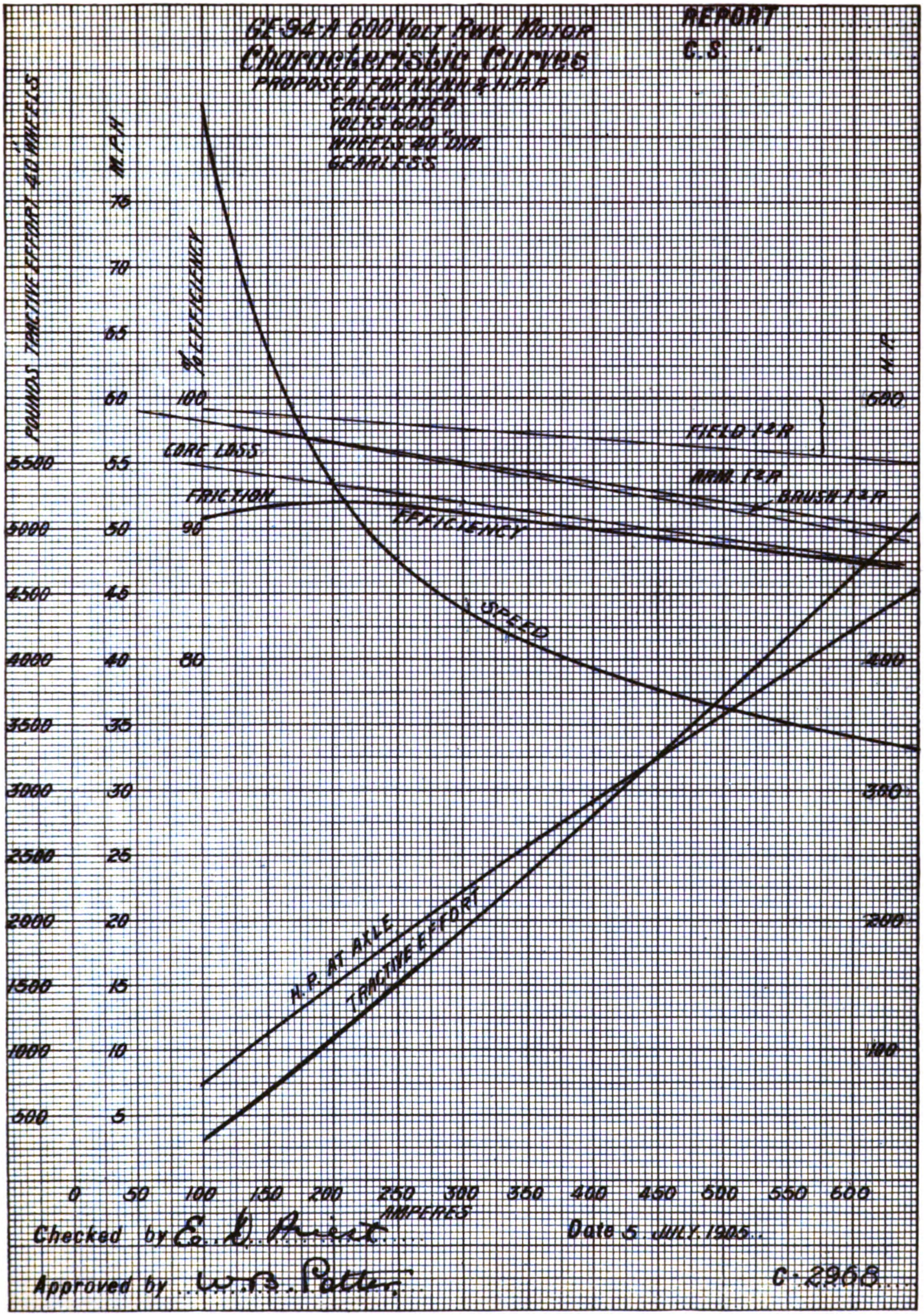
202944 GEA-608-A ALTERNATING CURRENT RAILWAY MOTOR. OUTLINE.

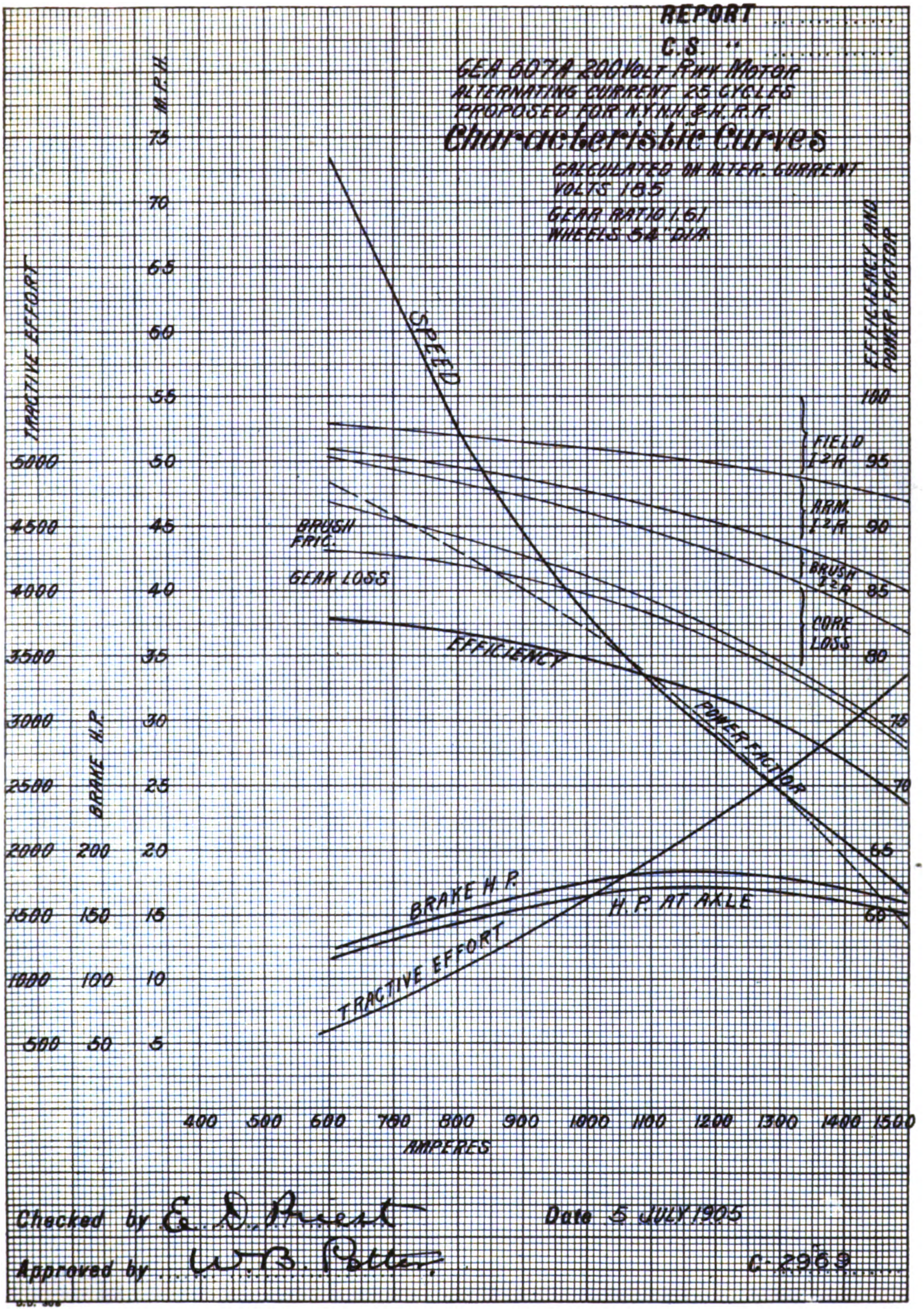


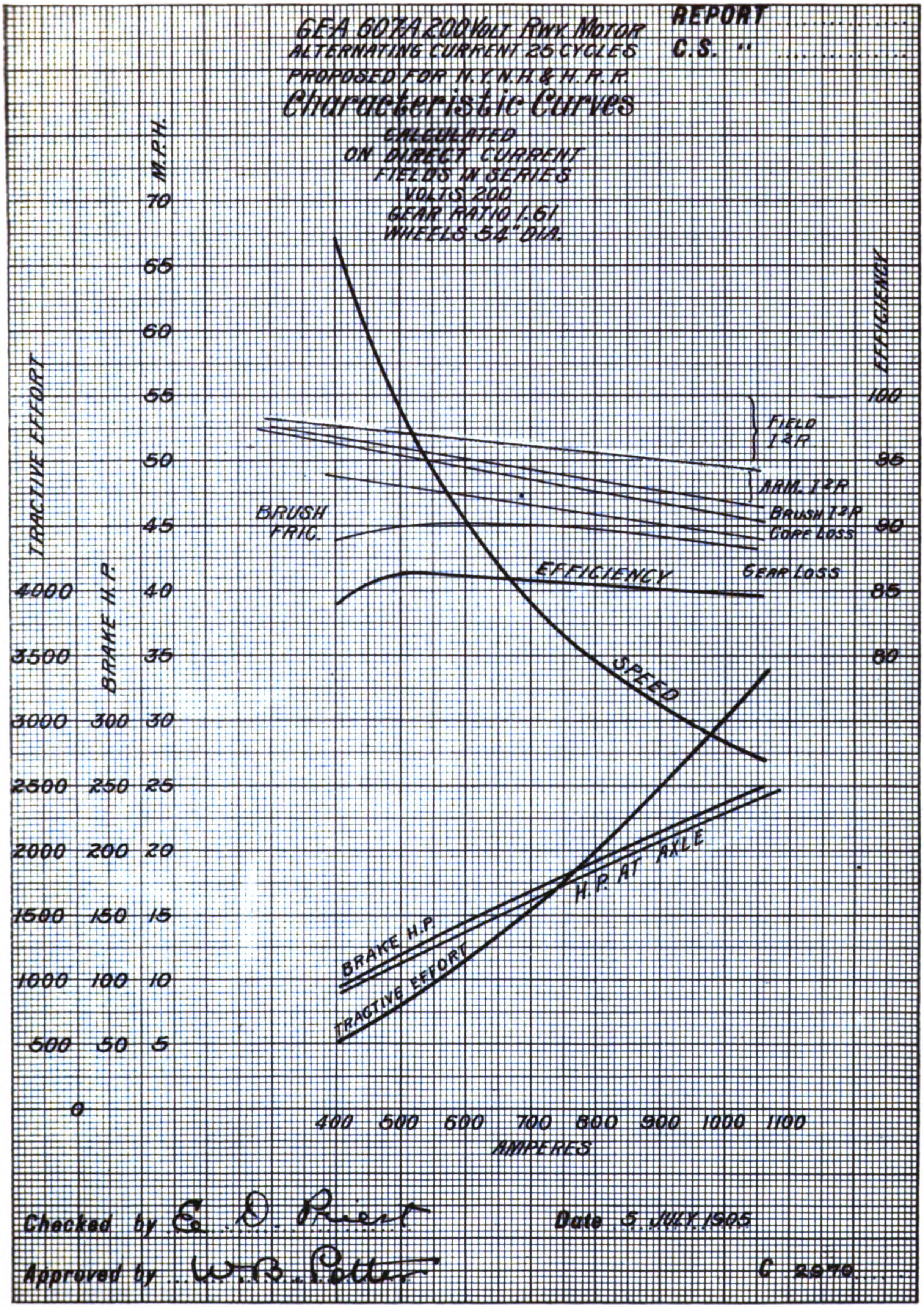
SUBJECT TO CHANGE. NOT FOR CONSTRUCTION UNLESS SPECIALLY APPROVED

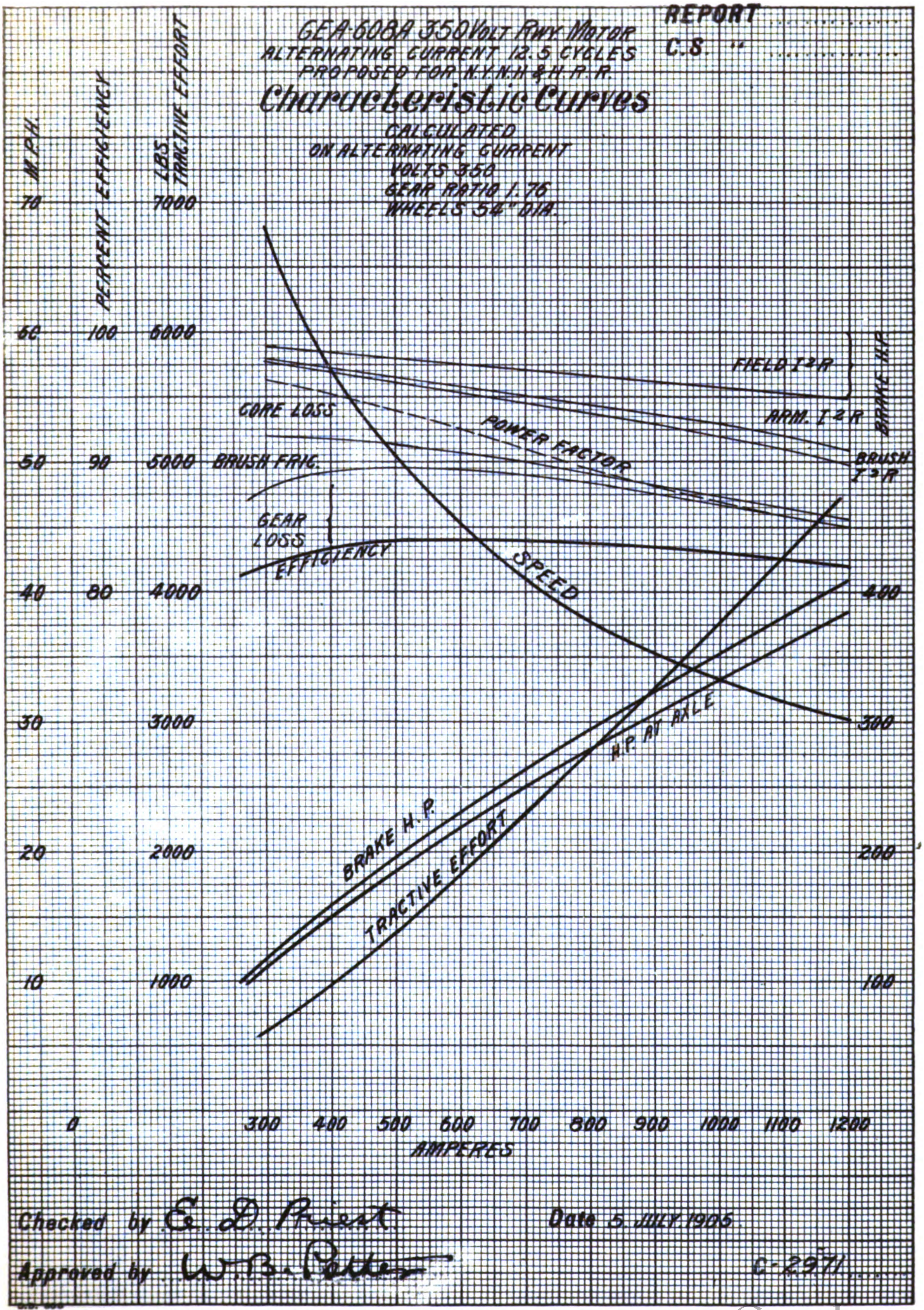
202965 GEA-609 ALTERNATING CURRENT RAILWAY MOTOR.
- OUTLINE.

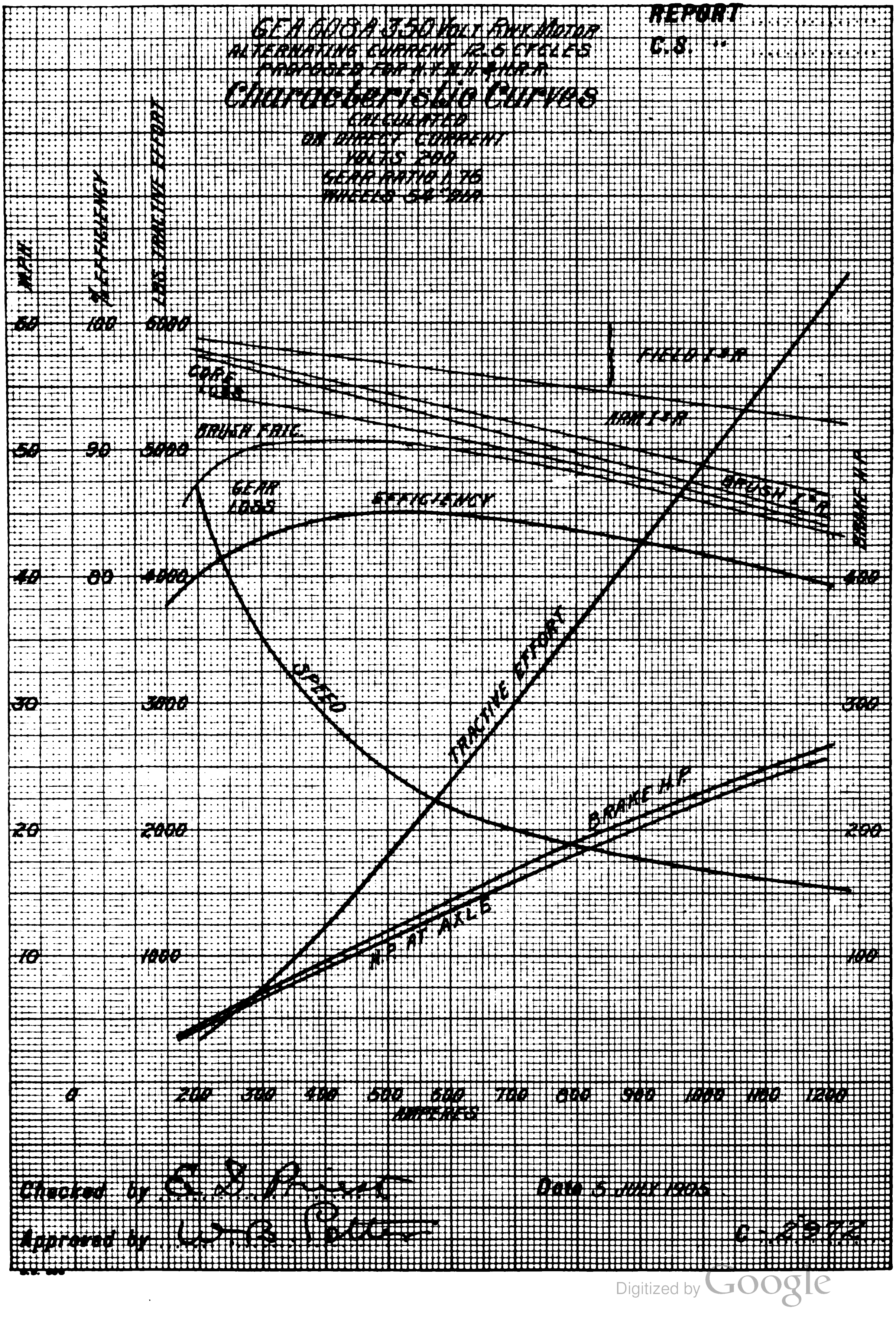

GE-84-A 600 Volt Rwy Motor
Characteristic Curves
PROPOSED FOR N.Y. N.H. & H.R.R.
TEST REPORT NO. 7254
VOLTS 600
WHEELS 44" DIA
GEARLESS
REPORT
C.S.
TRACTIVE EFFORT
M.P.H
EFFICIENCY
H.P.
7000 70
6000 60 100
95
5000 50 90
85
4000 40 80
75
3000 30 70
65
2000 20 60
55
1000 10 50
0 0
700
600
400
300
200
100
FRICTION
EFFICIENCY
SPEED
I^2R ARM
I^2R FIELD
I^2R BRUSH
CORE LOSS
H.P. AT AXLE
TRACTIVE EFFORT
0 100 200 300 400 500 600 700 800 900 1000
AMPERES
Checked by E. D. Priest
Approved by W. B. Potter
Date 5 JULY 1905
C-2967

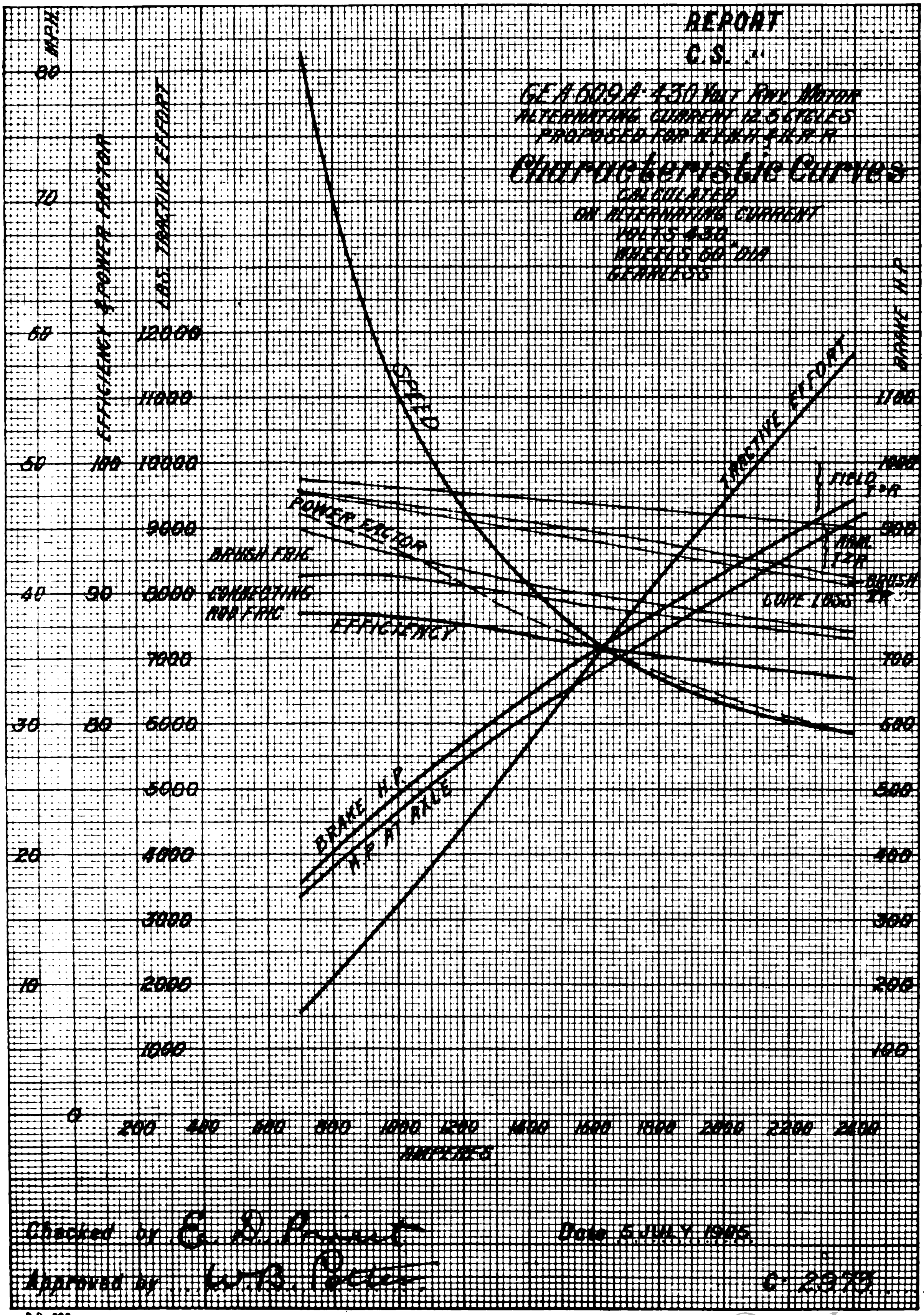

GE 94-A 600 Volt Rwy. Motor
Characteristic Curves
PROPOSED FOR N.Y.N.H.& H.R.R.
CALCULATED
VOLTS 600
WHEELS 40" DIA.
GEARLESS
REPORT
C.S.
POUNDS TRACTIVE EFFORT 40" WHEELS
M.P.H.
% EFFICIENCY
H.P.
FIELD I²R
CORE LOSS
ARM. I²R
BRUSH I²R
FRICTION
EFFICIENCY
SPEED
H.P. AT AXLE
TRACTIVE EFFORT
AMPERES
Checked by E. D. Priest
Date 5 JULY 1905
Approved by W. B. Potter
C-2968

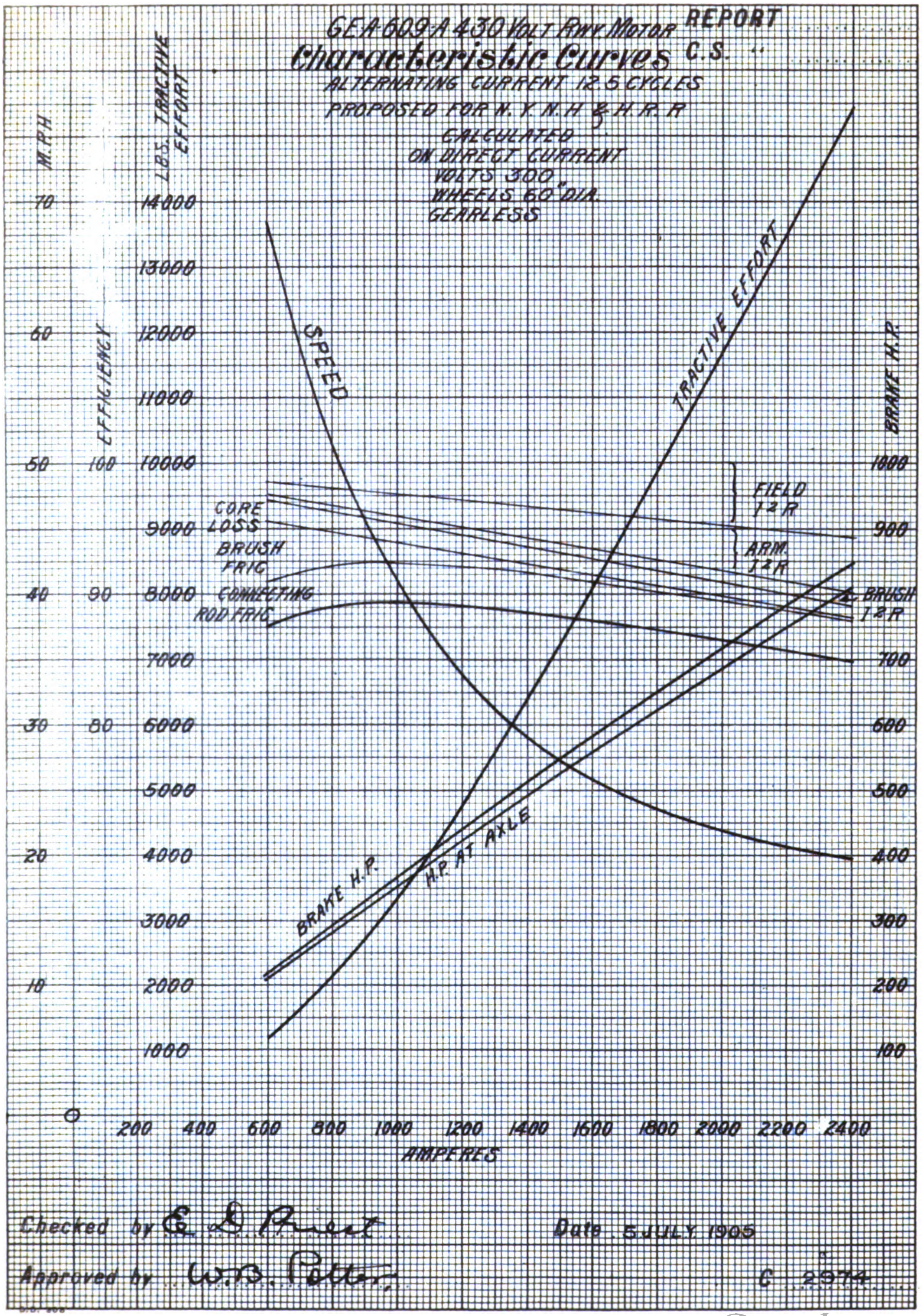

REPORT
C.S.
GEA 607A 200 Volt Rwy Motor
ALTERNATING CURRENT 25 CYCLES
PROPOSED FOR N.Y.N.H.&H.R.R.
Characteristic Curves
CALCULATED ON ALTER. CURRENT
VOLTS 185
GEAR RATIO 1.61
WHEELS 54" DIA.
TRACTIVE EFFORT
BRAKE H.P.
M.P.H.
EFFICIENCY AND POWER FACTOR
SPEED
FIELD I^2R
ARM. I^2R
BRUSH I^2R
CORE LOSS
BRUSH FRIC.
GEAR LOSS
EFFICIENCY
POWER FACTOR
BRAKE H.P.
H.P. AT AXLE
TRACTIVE EFFORT
AMPERES
400 500 600 700 800 900 1000 1100 1200 1300 1400 1500
5000 4500 4000 3500 3000 2500 2000 1500 1000 500
200 150 100 50
75 70 65 60 55 50 45 40 35 30 25 20 15 10 5
100 95 90 85 80 75 70 65 60
Checked by E. D. Priest
Date 5 JULY 1905
Approved by W. B. Potter
C-2969

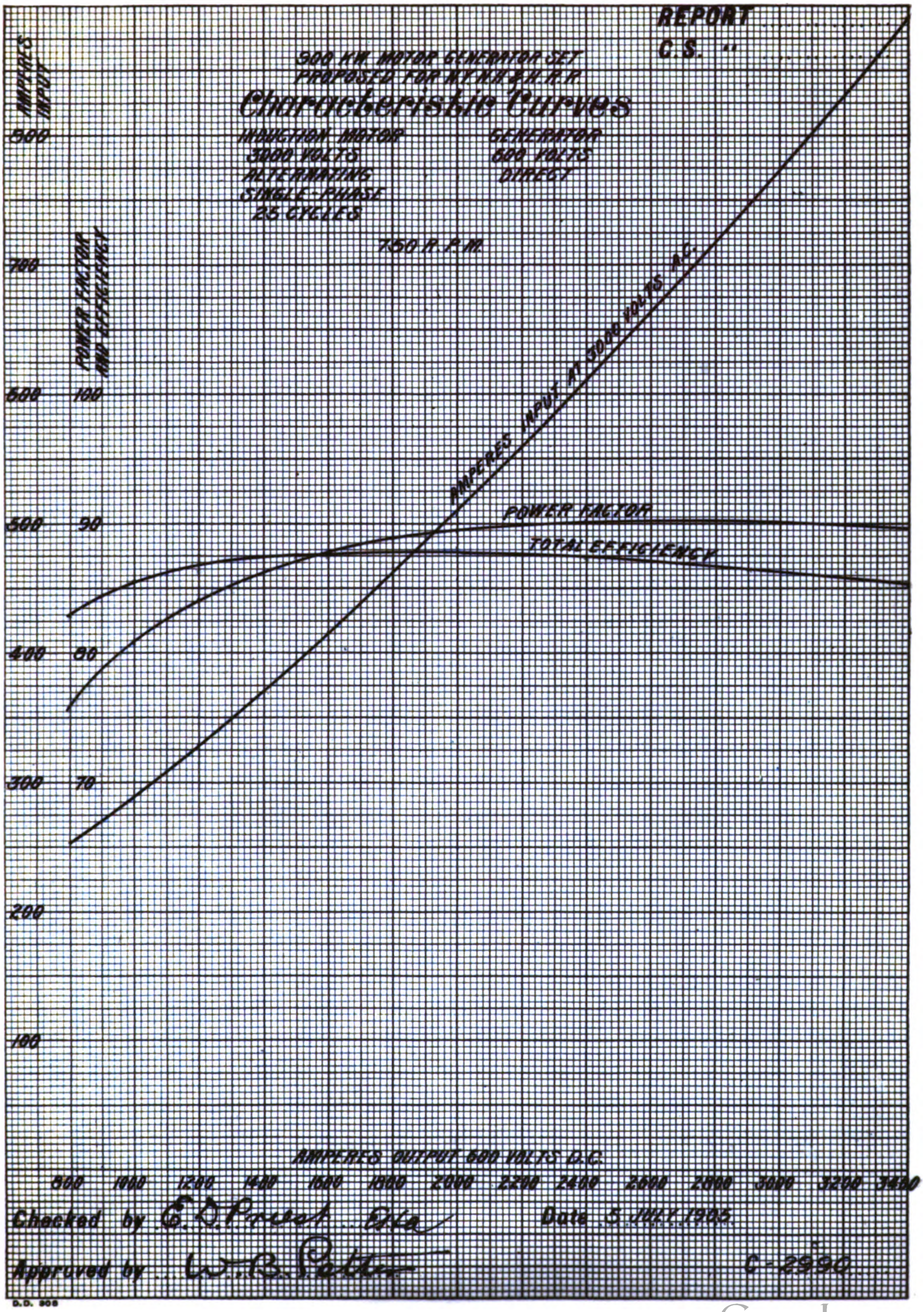

GEA 607-A 200 VOLT RWY MOTOR
ALTERNATING CURRENT 25 CYCLES
PROPOSED FOR N.Y. N.H. & H. R. R.
Characteristic Curves
CALCULATED
ON DIRECT CURRENT
FIELDS IN SERIES
VOLTS 200
GEAR RATIO 1.61
WHEELS 54" DIA.
REPORT
C.S.
M.P.H.
TRACTIVE EFFORT
BRAKE H.P.
EFFICIENCY
FIELD I²R
ARM. I²R
BRUSH I²R
CORE LOSS
GEAR LOSS
BRUSH FRIC.
EFFICIENCY
SPEED
H.P. AT AXLE
BRAKE H.P.
TRACTIVE EFFORT
AMPERES
400 500 600 700 800 900 1000 1100
Checked by E. D. Priest
Date 5. JULY. 1905
Approved by W. B. Potter
C 2970

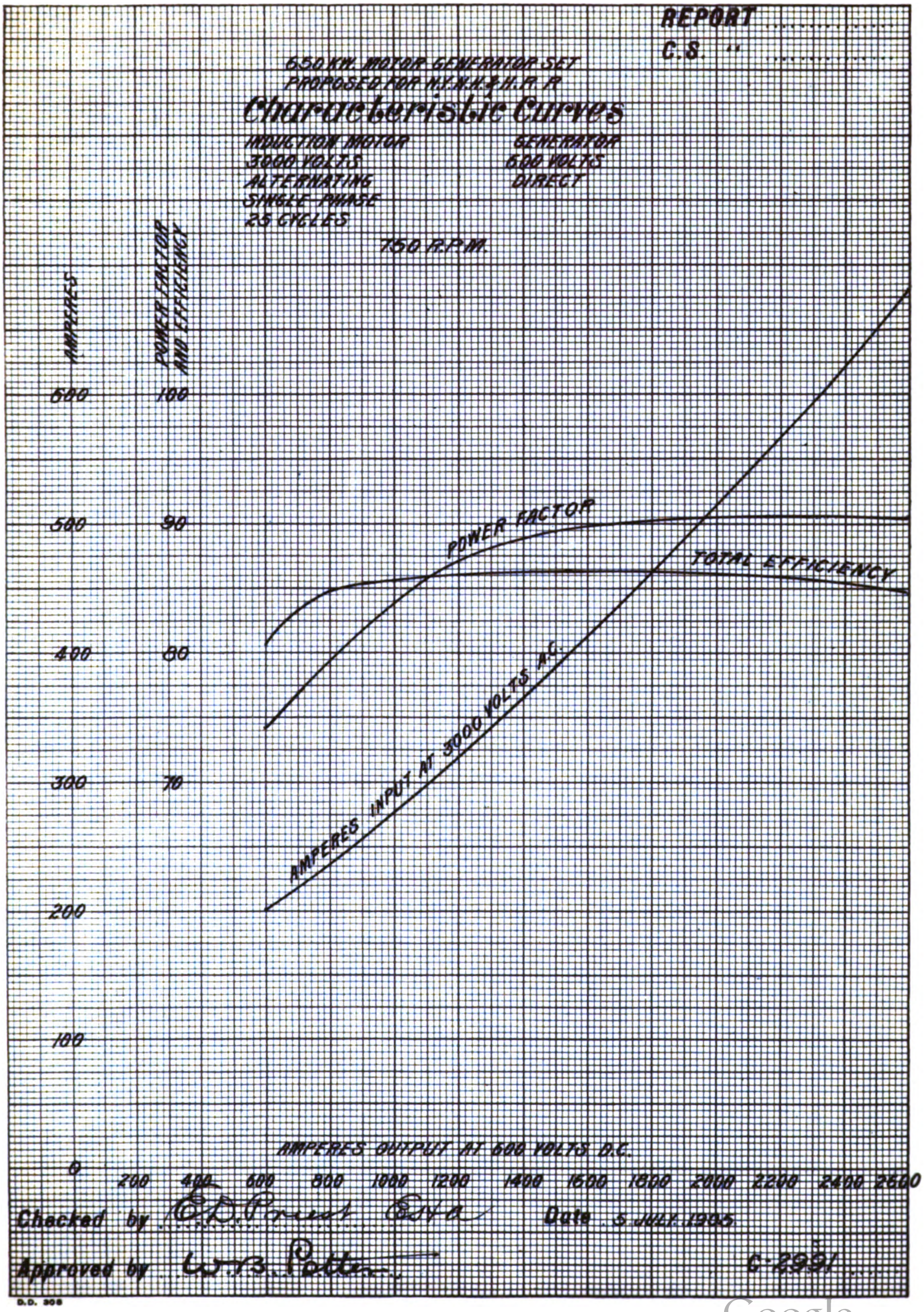

REPORT
C.S.
GEA-608A 350 VOLT RWY. MOTOR
ALTERNATING CURRENT 12.5 CYCLES
PROPOSED FOR N.Y.N.H.& H.R.R.
Characteristic Curves
CALCULATED
ON ALTERNATING CURRENT
VOLTS 350
GEAR RATIO 1.76
WHEELS 54" DIA.
M.P.H.
PERCENT EFFICIENCY
LBS. TRACTIVE EFFORT
70
7000
60
100
6000
50
90
5000
40
80
4000
30
3000
20
2000
10
1000
0
FIELD I²R
ARM. I²R
BRUSH I²R
BRAKE H.P.
CORE LOSS
POWER FACTOR
BRUSH FRIC.
GEAR LOSS
EFFICIENCY
SPEED
H.P. AT AXLE
BRAKE H.P.
TRACTIVE EFFORT
400
300
200
100
300
400
500
600
700
800
900
1000
1100
1200
AMPERES
Checked by E. D. Priest
Date 5 JULY 1905
Approved by W. B. Potter
C-2971

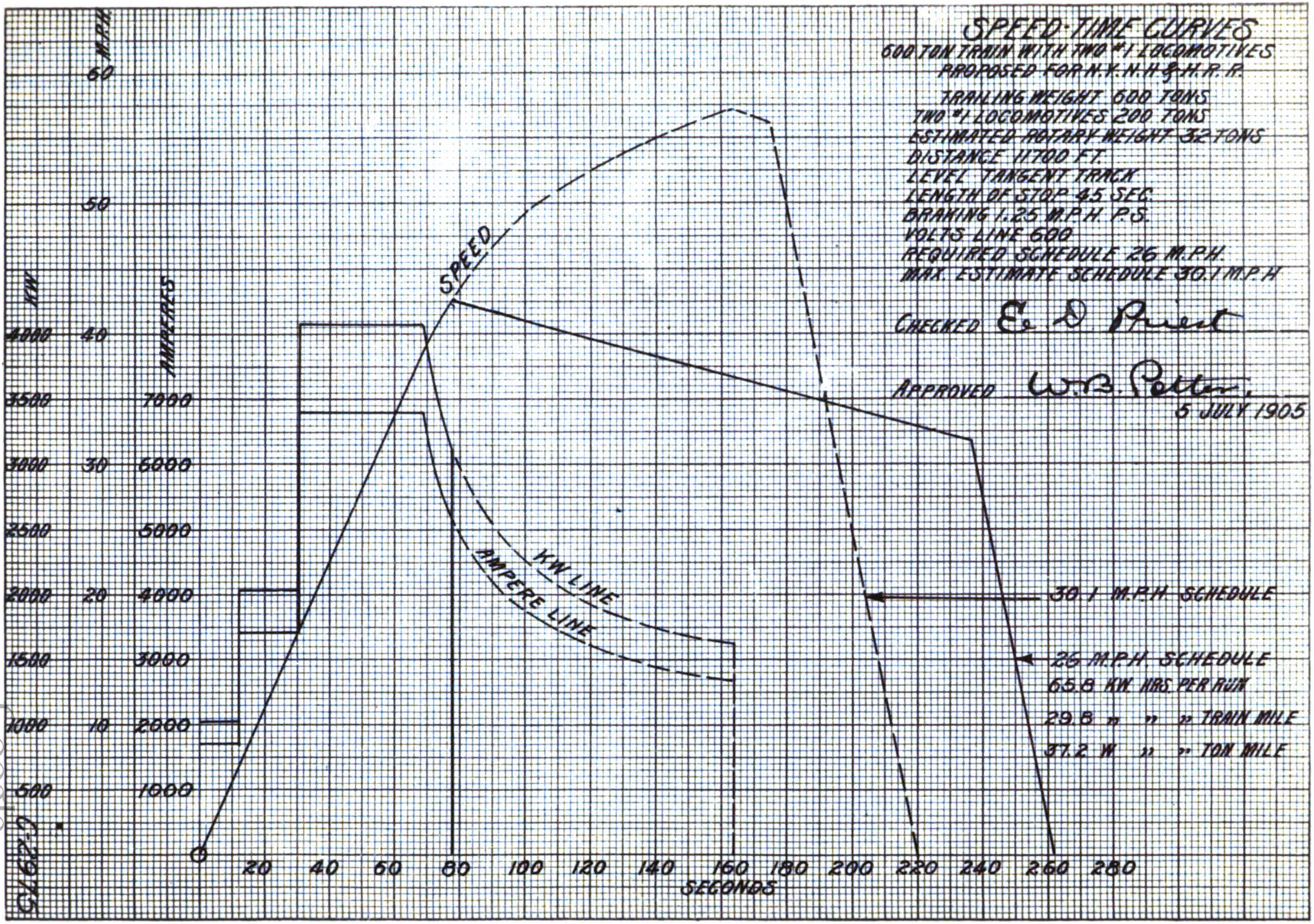

REPORT
C-8
GEA 608A 350 VOLT RWY. MOTOR
ALTERNATING CURRENT 12.5 CYCLES
PROPOSED FOR N.Y.N.H.&H.R.R.
Characteristic Curves
CALCULATED
ON DIRECT CURRENT
VOLTS 200
GEAR RATIO 1.76
WHEELS 54" DIAM.
M.P.H.
% EFFICIENCY
LBS. TRACTIVE EFFORT
FIELD I²R
CORE LOSS
ARM I²R
BRUSH FRIC.
GEAR LOSS
EFFICIENCY
BRUSH I²R
BRAKE H.P.
SPEED
TRACTIVE EFFORT
H.P. AT AXLE
AMPERES
Checked by
Date 5 JULY 1905
Approved by
C-2372

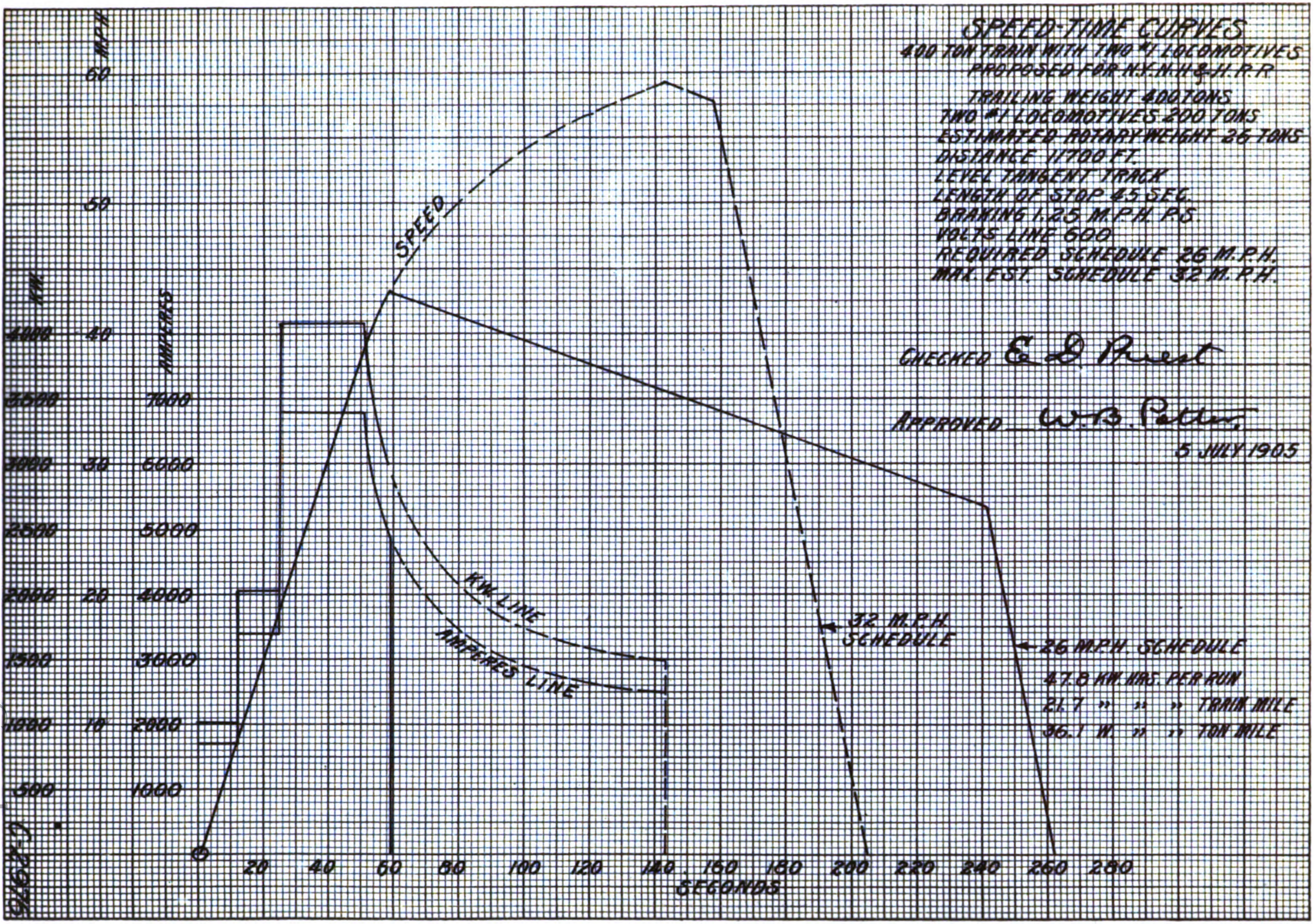

REPORT
C.S.
GE A 609 A 430 Volt Rwy Motor
ALTERNATING CURRENT 12.5 CYCLES
Characteristic Curves
CALCULATED
ON ALTERNATING CURRENT
VOLTS 430
WHEELS 60" DIA
GEARLESS
M.P.H.
EFFICIENCY & POWER FACTOR
LBS. TRACTIVE EFFORT
BRAKE H.P.
SPEED
TRACTIVE EFFORT
POWER FACTOR
BRUSH FRIC
CONNECTING ROD FRIC
EFFICIENCY
FIELD
BRUSH
CORE LOSS
BRAKE H.P.
H.P. AT AXLE
AMPERES
200
400
600
800
1000
1200
1400
1600
1800
2000
2200
2400
80
70
60
50
40
30
20
10
0
100
90
80
12000
11000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
1100
1000
900
800
700
600
500
400
300
200
100
Checked by E. D. Priest
Date 5 JULY 1905.
Approved by W. B. Potter
C 2375

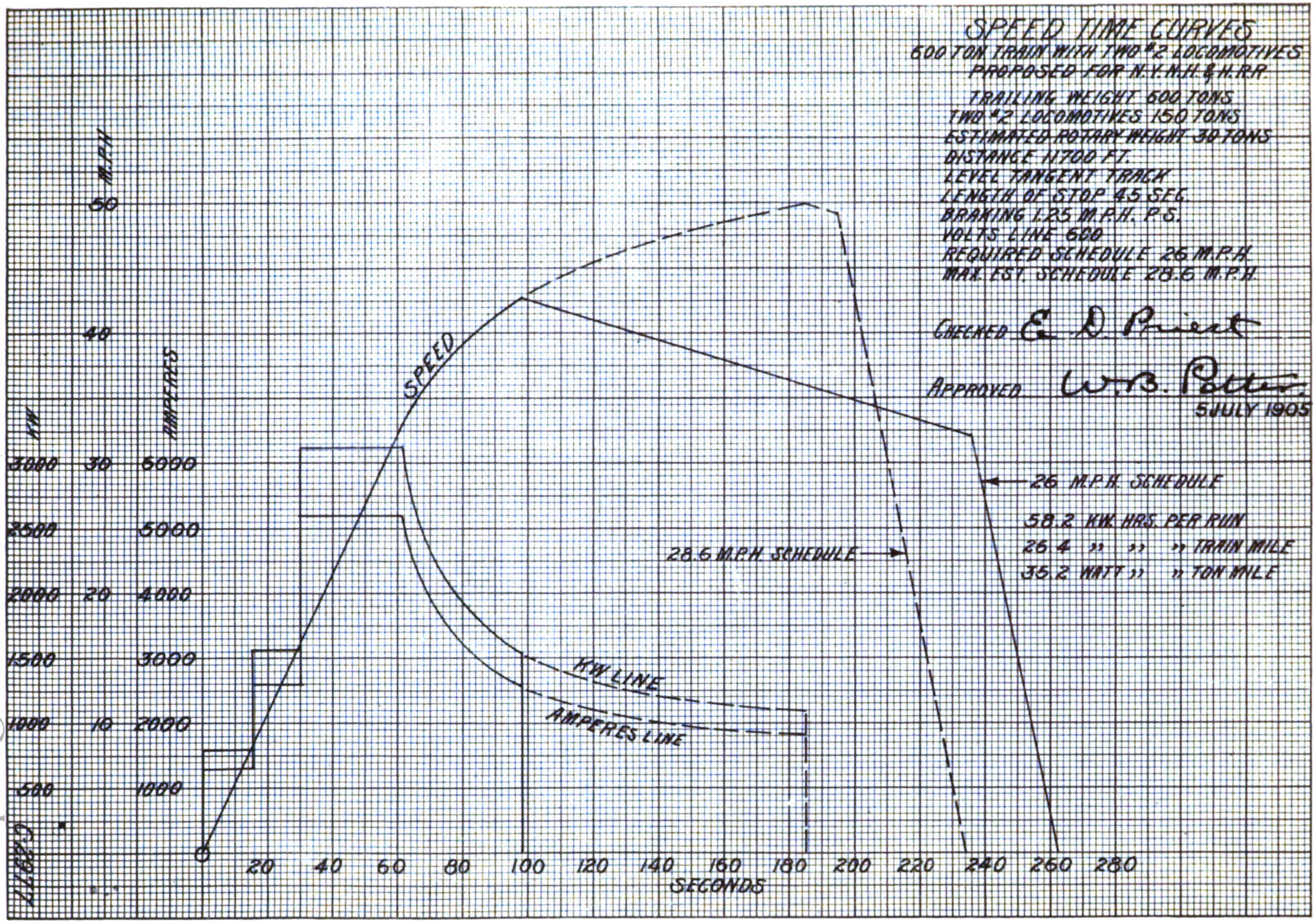

GE.A-609-A 430 VOLT RWY MOTOR
REPORT
Characteristic Curves
C.S.
ALTERNATING CURRENT 12.5 CYCLES
PROPOSED FOR N. Y. N. H & H. R. R
CALCULATED
ON DIRECT CURRENT
VOLTS 300
WHEELS 60" DIA.
GEARLESS
M.P.H
LBS. TRACTIVE EFFORT
EFFICIENCY
BRAKE H.P.
SPEED
TRACTIVE EFFORT
FIELD I^2R
ARM. I^2R
BRUSH I^2R
CORE LOSS
BRUSH FRIC
CONNECTING ROD FRIC
BRAKE H.P.
H.P. AT AXLE
AMPERES
Checked by E. D. Priest
Date 5 JULY 1905
Approved by W. B. Potter
C 2974


REPORT
C.S. "
900 KW. MOTOR GENERATOR SET
PROPOSED FOR N.Y.N.H.& H.R.R.
Characteristic Curves
INDUCTION MOTOR
3000 VOLTS
ALTERNATING
SINGLE-PHASE
25 CYCLES
GENERATOR
600 VOLTS
DIRECT
750 R.P.M.
AMPERES INPUT
POWER FACTOR AND EFFICIENCY
AMPERES INPUT AT 3000 VOLTS A.C.
POWER FACTOR
TOTAL EFFICIENCY
800
700
600 100
500 90
400 80
300 70
200
100
AMPERES OUTPUT 600 VOLTS D.C.
800 1000 1200 1400 1600 1800 2000 2200 2400 2600 2800 3000 3200 3400
Checked by E. D. Priest Eda
Date 5 JULY 1905
Approved by W. B. Potter
C-2990
D.D. 908

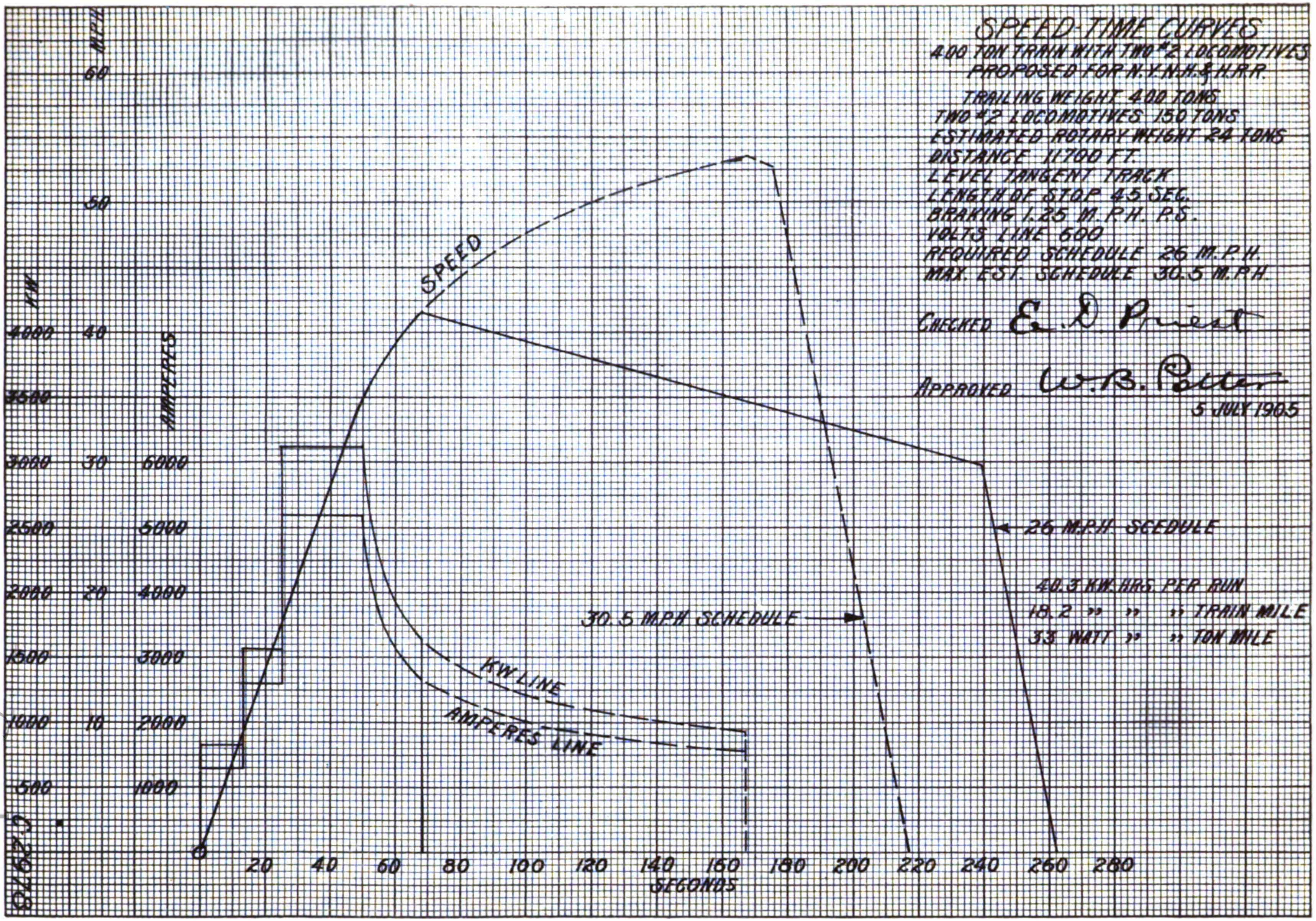

REPORT
C.S. "
650 KW. MOTOR GENERATOR SET
PROPOSED FOR N.Y.N.H.& H.R.R.
Characteristic Curves
INDUCTION MOTOR
3000 VOLTS
ALTERNATING
SINGLE PHASE
25 CYCLES
GENERATOR
600 VOLTS
DIRECT
750 R.P.M.
AMPERES
POWER FACTOR AND EFFICIENCY
600 100
500 90
400 80
300 70
200
100
0
POWER FACTOR
TOTAL EFFICIENCY
AMPERES INPUT AT 3000 VOLTS A.C.
AMPERES OUTPUT AT 600 VOLTS D.C.
200 400 600 800 1000 1200 1400 1600 1800 2000 2200 2400 2600
Checked by E.D. Priest
Date 5 JULY 1905
Approved by W.B. Potter
C-2991
D.D. 308

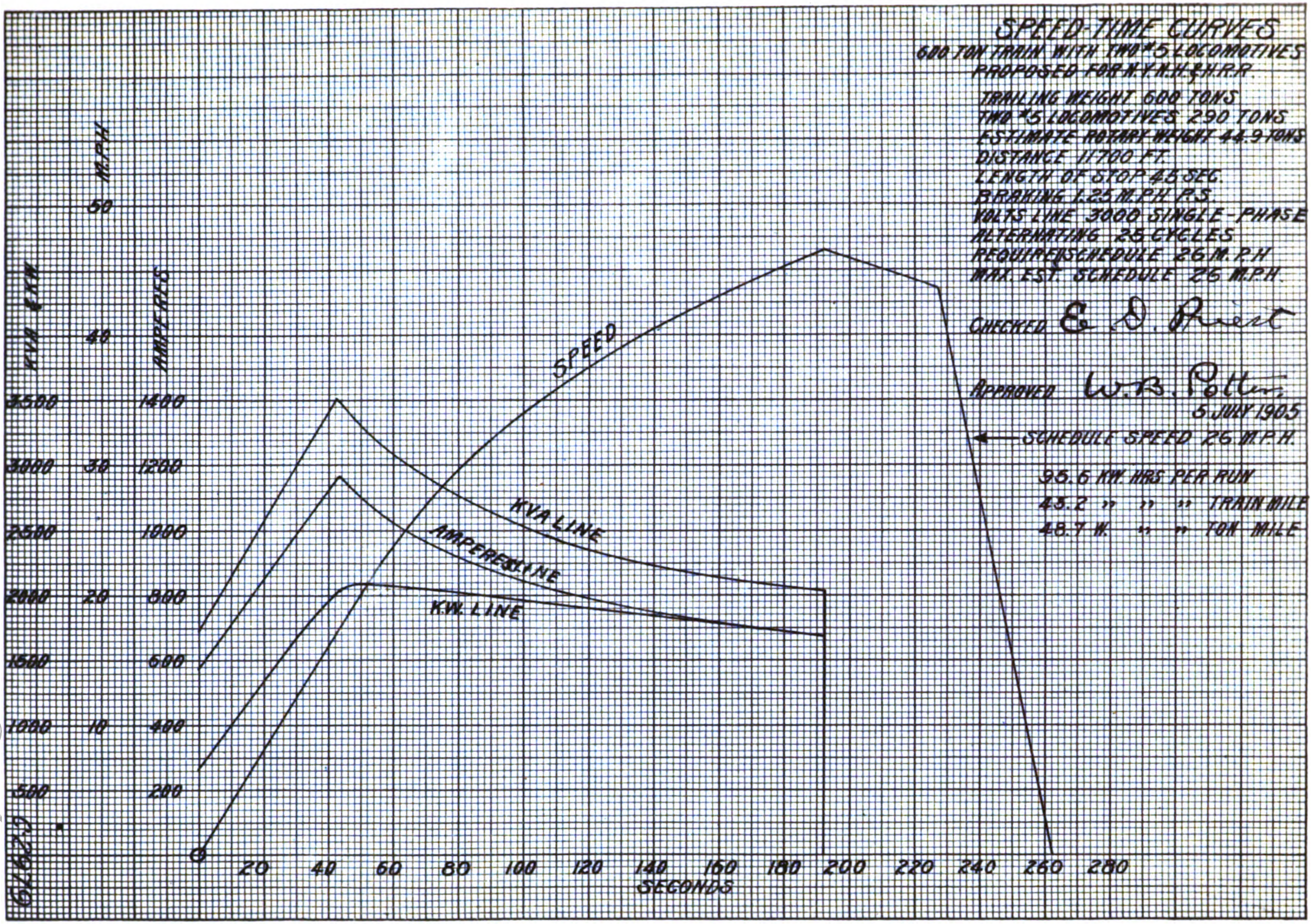

SPEED-TIME CURVES
600 TON TRAIN WITH TWO #1 LOCOMOTIVES
PROPOSED FOR N.Y. N.H. & H. R.R.
TRAILING WEIGHT 600 TONS
TWO #1 LOCOMOTIVES 200 TONS
ESTIMATED ROTARY WEIGHT 32 TONS
DISTANCE 11700 FT.
LEVEL TANGENT TRACK
LENGTH OF STOP 45 SEC.
BRAKING 1.25 M.P.H. P.S.
VOLTS LINE 600
REQUIRED SCHEDULE 26 M.P.H.
MAX. ESTIMATE SCHEDULE 30.1 M.P.H.
CHECKED E. D. Priest
APPROVED W. B. Potter
5 JULY 1905
SPEED
KW LINE
AMPERE LINE
30.1 M.P.H. SCHEDULE
26 M.P.H. SCHEDULE
65.8 KW. HRS. PER RUN
29.8 " " " TRAIN MILE
37.2 W " " TON MILE
M.P.H.
KW
AMPERES
SECONDS
C-2975

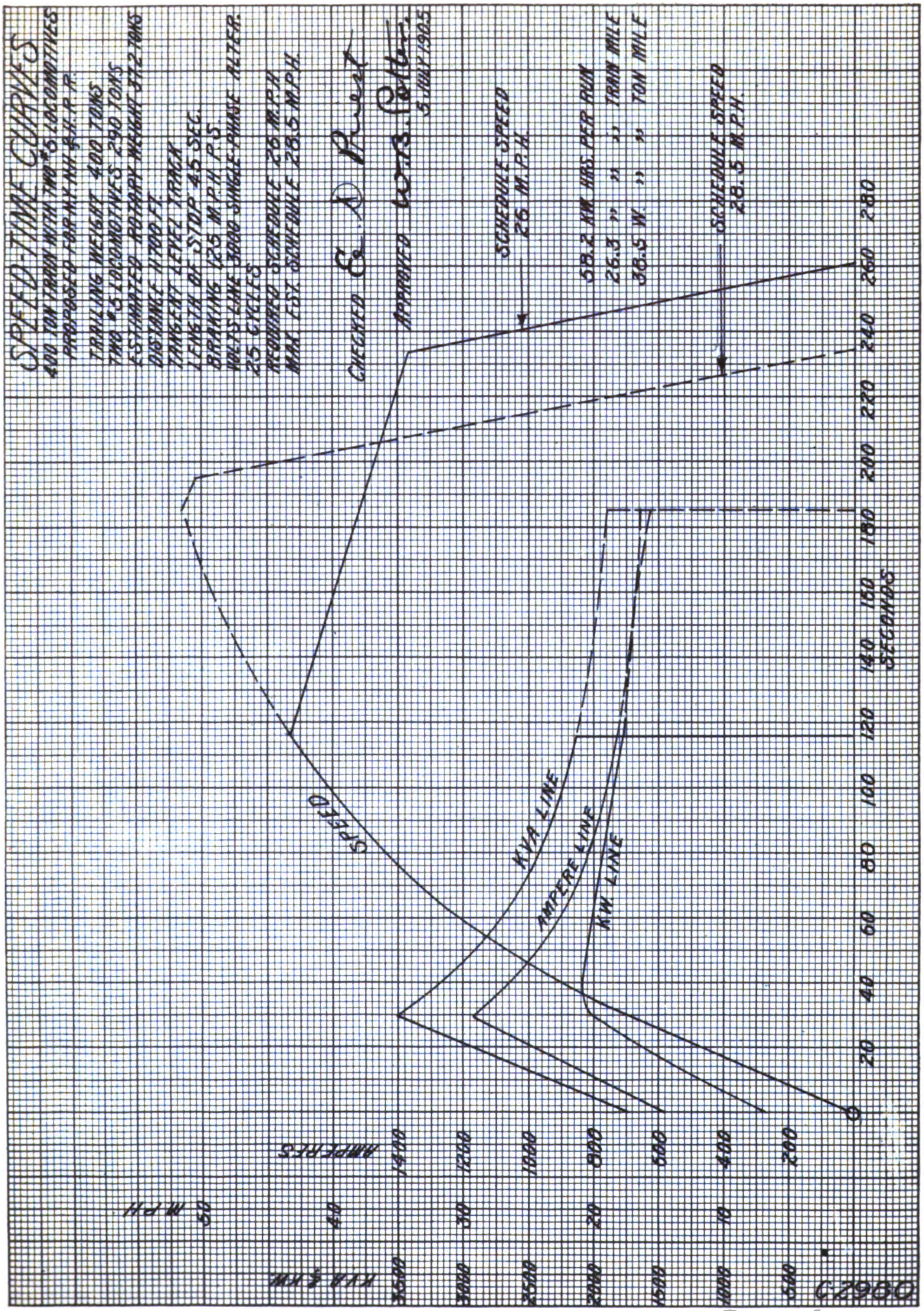

SPEED-TIME CURVES
400 TON TRAIN WITH TWO #1 LOCOMOTIVES
PROPOSED FOR N.Y. N.H. & H. R.R.
TRAILING WEIGHT 400 TONS
TWO #1 LOCOMOTIVES 200 TONS
ESTIMATED ROTARY WEIGHT 26 TONS
DISTANCE 11700 FT.
LEVEL TANGENT TRACK
LENGTH OF STOP 45 SEC.
BRAKING 1.25 M.P.H. P.S.
VOLTS LINE 600
REQUIRED SCHEDULE 26 M.P.H.
MAX. EST. SCHEDULE 32 M.P.H.
CHECKED E. D. Priest
APPROVED W. B. Potter
5 JULY 1905
SPEED
KW. LINE
AMPERES LINE
32 M.P.H. SCHEDULE
26 M.P.H. SCHEDULE
47.8 KW. HRS. PER RUN
21.7 " " " TRAIN MILE
36.1 W. " " TON MILE
M.P.H.
60
50
40
30
20
10
KW.
4000
3500
3000
2500
2000
1500
1000
500
AMPERES
7000
6000
5000
4000
3000
2000
1000
20
40
60
80
100
120
140
160
180
200
220
240
260
280
SECONDS
C-2976

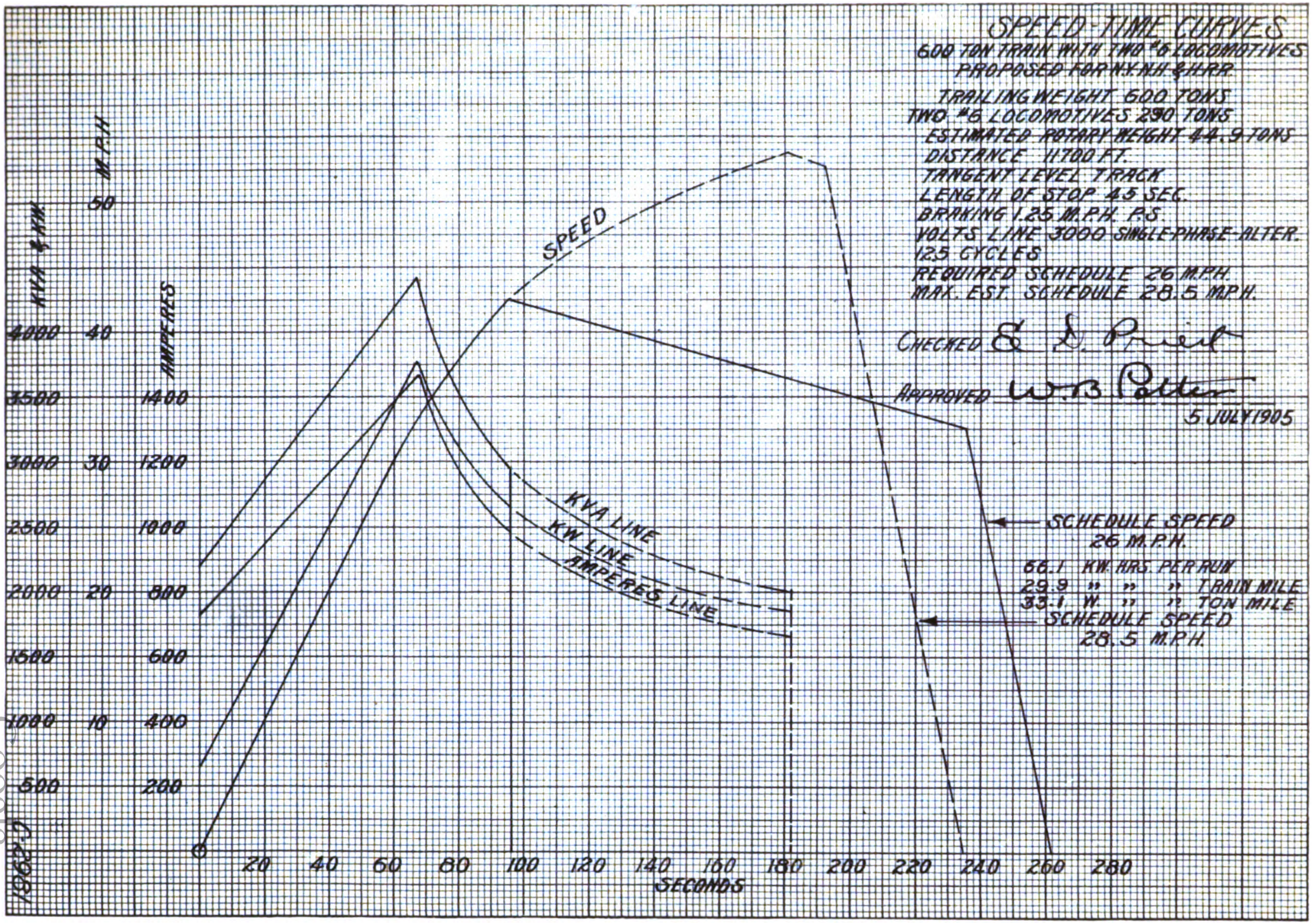


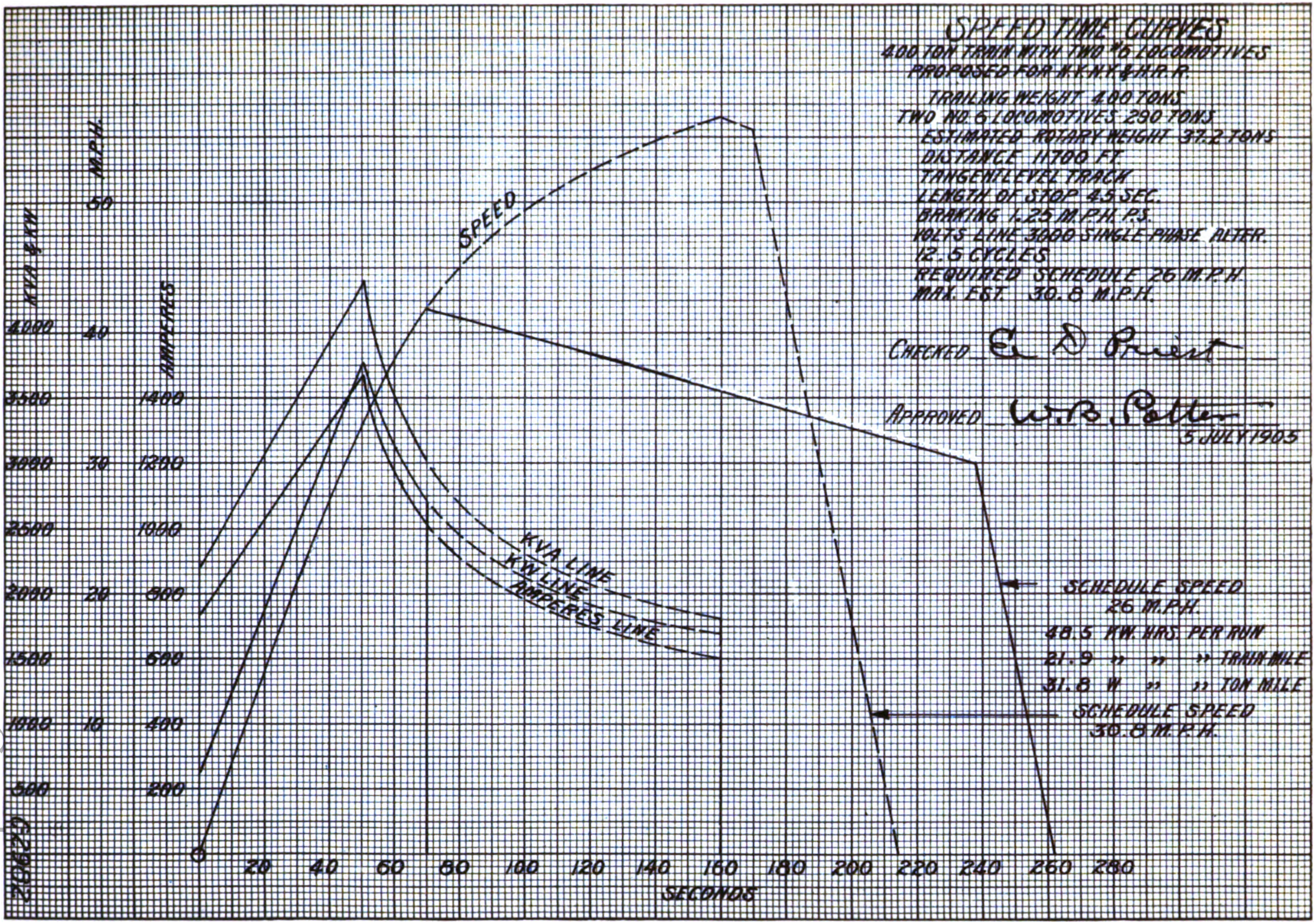
SPEED TIME CURVES
600 TON TRAIN WITH TWO #2 LOCOMOTIVES
PROPOSED FOR N.Y.N.H.& H.R.R.
TRAILING WEIGHT 600 TONS
TWO #2 LOCOMOTIVES 150 TONS
ESTIMATED ROTARY WEIGHT 30 TONS
DISTANCE 11700 FT.
LEVEL TANGENT TRACK
LENGTH OF STOP 45 SEC.
BRAKING 1.25 M.P.H. P.S.
VOLTS LINE 600
REQUIRED SCHEDULE 26 M.P.H.
MAX. EST. SCHEDULE 28.6 M.P.H.
CHECKED E. D. Priest
APPROVED W. B. Potter
5 JULY 1905
26 M.P.H. SCHEDULE
58.2 KW. HRS. PER RUN
26.4 " " " TRAIN MILE
35.2 WATT " " TON MILE
28.6 M.P.H. SCHEDULE
SPEED
KW LINE
AMPERES LINE
SECONDS
M.P.H.
KW
AMPERES
G2977

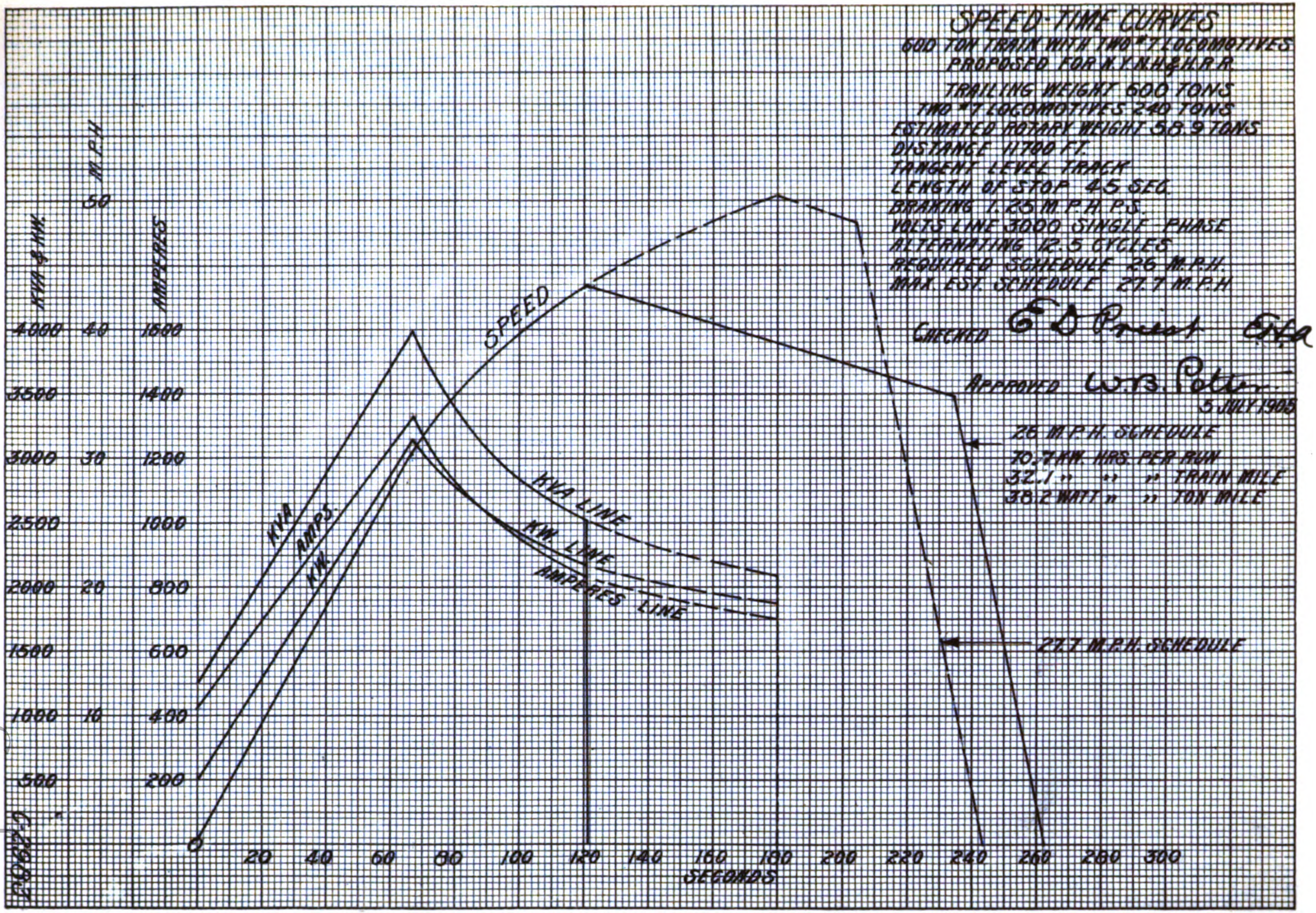

SPEED-TIME CURVES
400 TON TRAIN WITH TWO #2 LOCOMOTIVES
PROPOSED FOR N.Y.N.H.& H.R.R.
TRAILING WEIGHT 400 TONS
TWO #2 LOCOMOTIVES 150 TONS
ESTIMATED ROTARY WEIGHT 24 TONS
DISTANCE 11700 FT.
LEVEL TANGENT TRACK
LENGTH OF STOP 45 SEC.
BRAKING 1.25 M.P.H. P.S.
VOLTS LINE 600
REQUIRED SCHEDULE 26 M.P.H.
MAX. EST. SCHEDULE 30.5 M.P.H.
CHECKED E. D. Priest
APPROVED W. B. Potter
5 JULY 1905
SPEED
KW LINE
AMPERES LINE
30.5 M.P.H. SCHEDULE
26 M.P.H. SCEDULE
40.3 KW. HRS. PER RUN
18.2 " " " TRAIN MILE
33 WATT " " TON MILE
KW
M.P.H.
AMPERES
SECONDS
C.2978

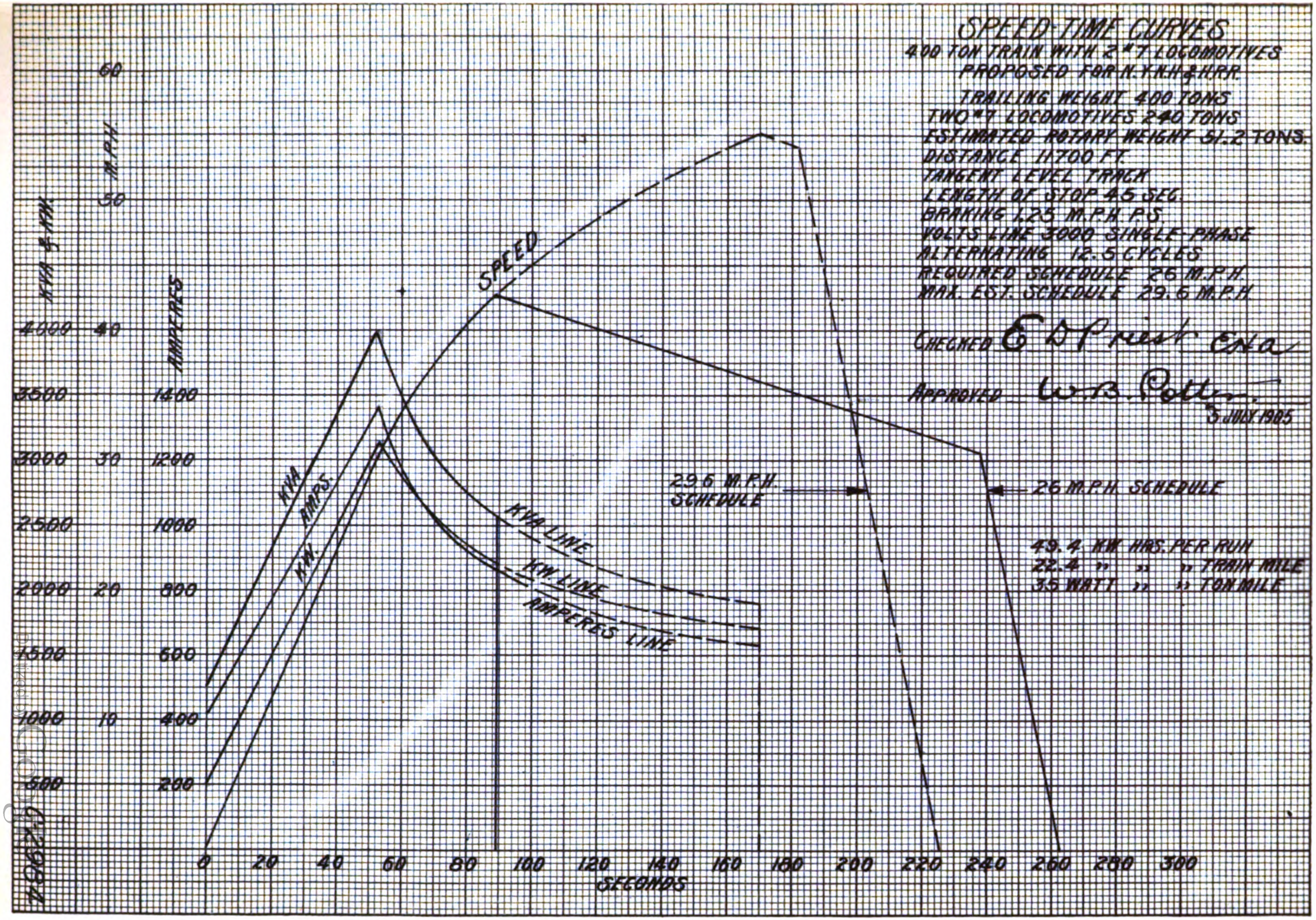

SPEED-TIME CURVES
600 TON TRAIN WITH TWO #5 LOCOMOTIVES
PROPOSED FOR N.Y.N.H.&H.R.R.
TRAILING WEIGHT 600 TONS
TWO #5 LOCOMOTIVES 290 TONS
ESTIMATE ROTARY WEIGHT 44.9 TONS
DISTANCE 11700 FT.
LENGTH OF STOP 45 SEC.
BRAKING 1.25 M.P.H.P.S.
VOLTS LINE 3000 SINGLE-PHASE
ALTERNATING 25 CYCLES
REQUIRED SCHEDULE 26 M.P.H
MAX. EST. SCHEDULE 26 M.P.H.
CHECKED E. D. Priest
APPROVED W. B. Potter
5 JULY 1905
SCHEDULE SPEED 26 M.P.H.
95.6 KW. HRS PER RUN
43.2 " " " TRAIN MILE
48.7 W. " " TON MILE
SPEED
KVA LINE
AMPERE LINE
KW. LINE
KVA & KW
M.P.H
AMPERES
SECONDS
C2979

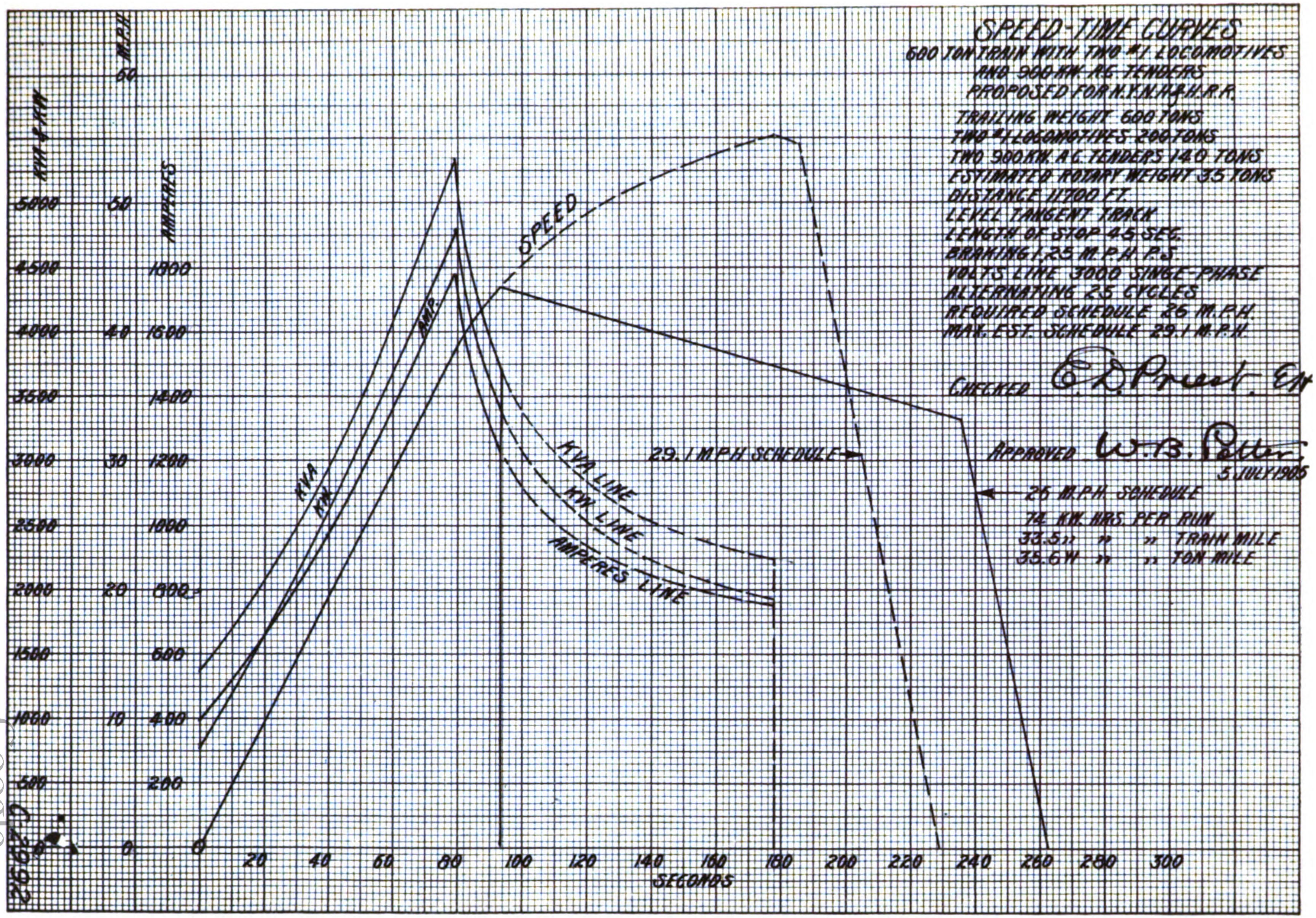

SPEED-TIME CURVES
400 TON TRAIN WITH TWO #5 LOCOMOTIVES
PROPOSED FOR N.Y. N.H. & H. R.R.
TRAILING WEIGHT 400 TONS
TWO #5 LOCOMOTIVES 290 TONS
ESTIMATED ROTARY WEIGHT 872 TONS
DISTANCE 11700 FT.
TANGENT LEVEL TRACK
LENGTH OF STOP 45 SEC.
BRAKING 1.25 M.P.H. P.S.
VOLTS LINE 3000 SINGLE-PHASE ALTER.
25 CYCLES
REQUIRED SCHEDULE 26 M.P.H.
MAX. FOT. SCHEDULE 28.5 M.P.H.
CHECKED
APPROVED
5 JULY 1905
SCHEDULE SPEED 26 M.P.H.
58.2 KW. HRS. PER RUN
26.3 " " " TRAIN MILE
36.5 W. " " TON MILE
SCHEDULE SPEED 28.5 M.P.H.
SPEED
KVA LINE
AMPERE LINE
KW LINE
SECONDS
20 40 60 80 100 120 140 160 180 200 220 240 260 280
AMPERES
200 400 600 800 1000 1200 1400
M.P.H.
10 20 30 40 50
KVA & KW
500 1000 1500 2000 2500 3000 3500
C2980

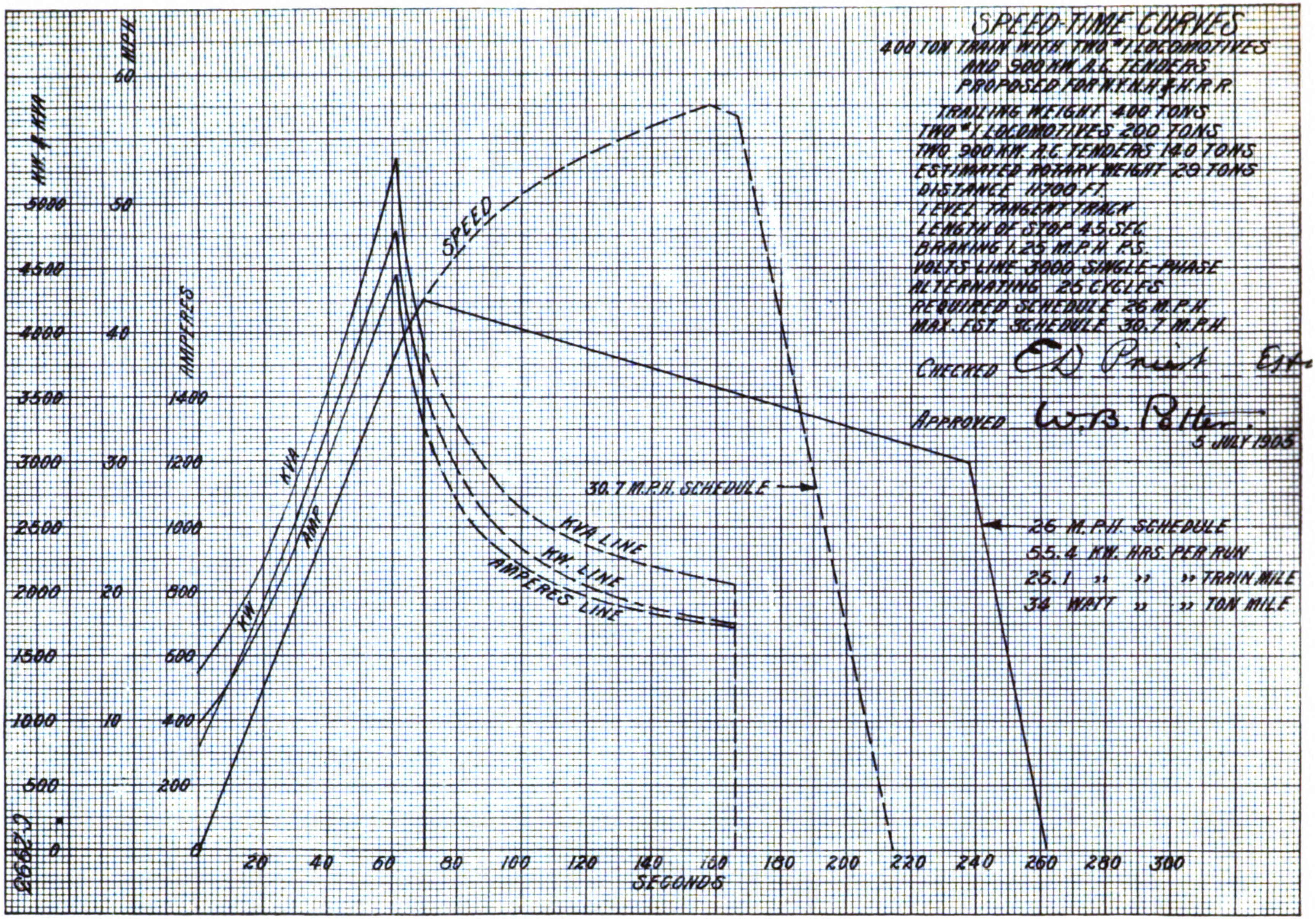

SPEED-TIME CURVES
600 TON TRAIN WITH TWO #6 LOCOMOTIVES
PROPOSED FOR N.Y. N.H. & H.R.R.
TRAILING WEIGHT 600 TONS
TWO #6 LOCOMOTIVES 290 TONS
ESTIMATED ROTARY WEIGHT 44.9 TONS
DISTANCE 11700 FT.
TANGENT LEVEL TRACK
LENGTH OF STOP 45 SEC.
BRAKING 1.25 M.P.H. P.S.
VOLTS LINE 3000 SINGLE-PHASE-ALTER.
125 CYCLES
REQUIRED SCHEDULE 26 M.P.H.
MAX. EST. SCHEDULE 28.5 M.P.H.
CHECKED E. D. Priest
APPROVED W. B. Potter
5 JULY 1905
SPEED
KVA LINE
KW LINE
AMPERES LINE
SCHEDULE SPEED
26 M.P.H.
66.1 KW. HRS. PER RUN
29.9 " " " TRAIN MILE
33.1 W. " " TON MILE
SCHEDULE SPEED
28.5 M.P.H.
KVA & KW
M.P.H.
AMPERES
4000
3500
3000
2500
2000
1500
1000
500
50
40
30
20
10
1400
1200
1000
800
600
400
200
20
40
60
80
100
120
140
160
180
200
220
240
260
280
SECONDS
C-2981

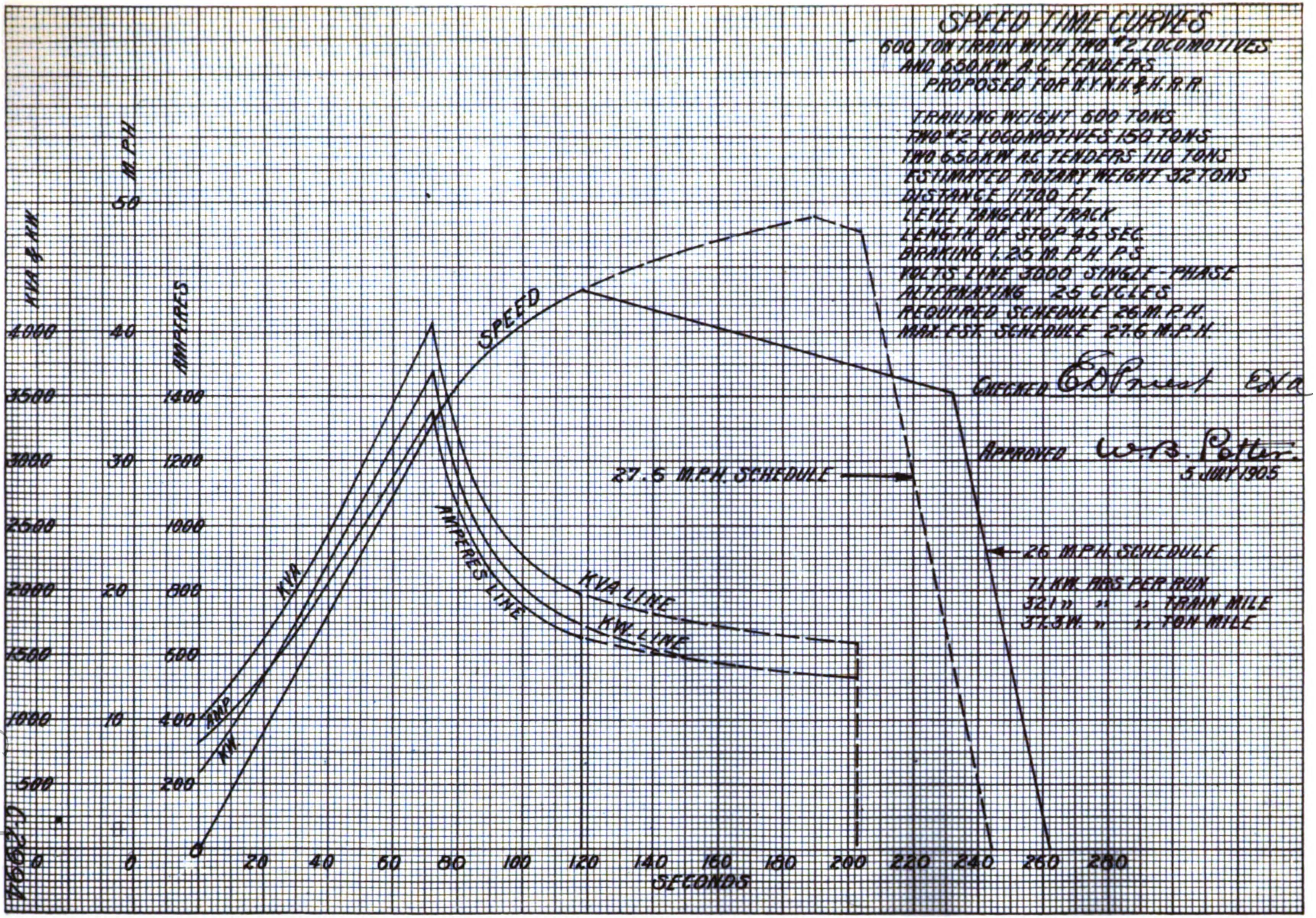

SPEED TIME CURVES
400 TON TRAIN WITH TWO #6 LOCOMOTIVES
PROPOSED FOR N.Y.N.H.&H.R.R.
TRAILING WEIGHT 400 TONS
TWO NO. 6 LOCOMOTIVES 290 TONS
ESTIMATED ROTARY WEIGHT 37.2 TONS
DISTANCE 11700 FT.
TANGENT LEVEL TRACK
LENGTH OF STOP 45 SEC.
BRAKING 1.25 M.P.H. P.S.
VOLTS LINE 3000 SINGLE PHASE ALTER.
12.5 CYCLES
REQUIRED SCHEDULE 26 M.P.H.
MAX. EST. 30.8 M.P.H.
CHECKED E. D. Priest
APPROVED W. B. Potter
5 JULY 1905
SPEED
KVA LINE
KW LINE
AMPERES LINE
SCHEDULE SPEED
26 M.P.H.
48.5 KW. HRS. PER RUN
21.9 " " " TRAIN MILE
31.8 W " " TON MILE
SCHEDULE SPEED
30.8 M.P.H.
KVA & KW
M.P.H.
AMPERES
SECONDS
C2902

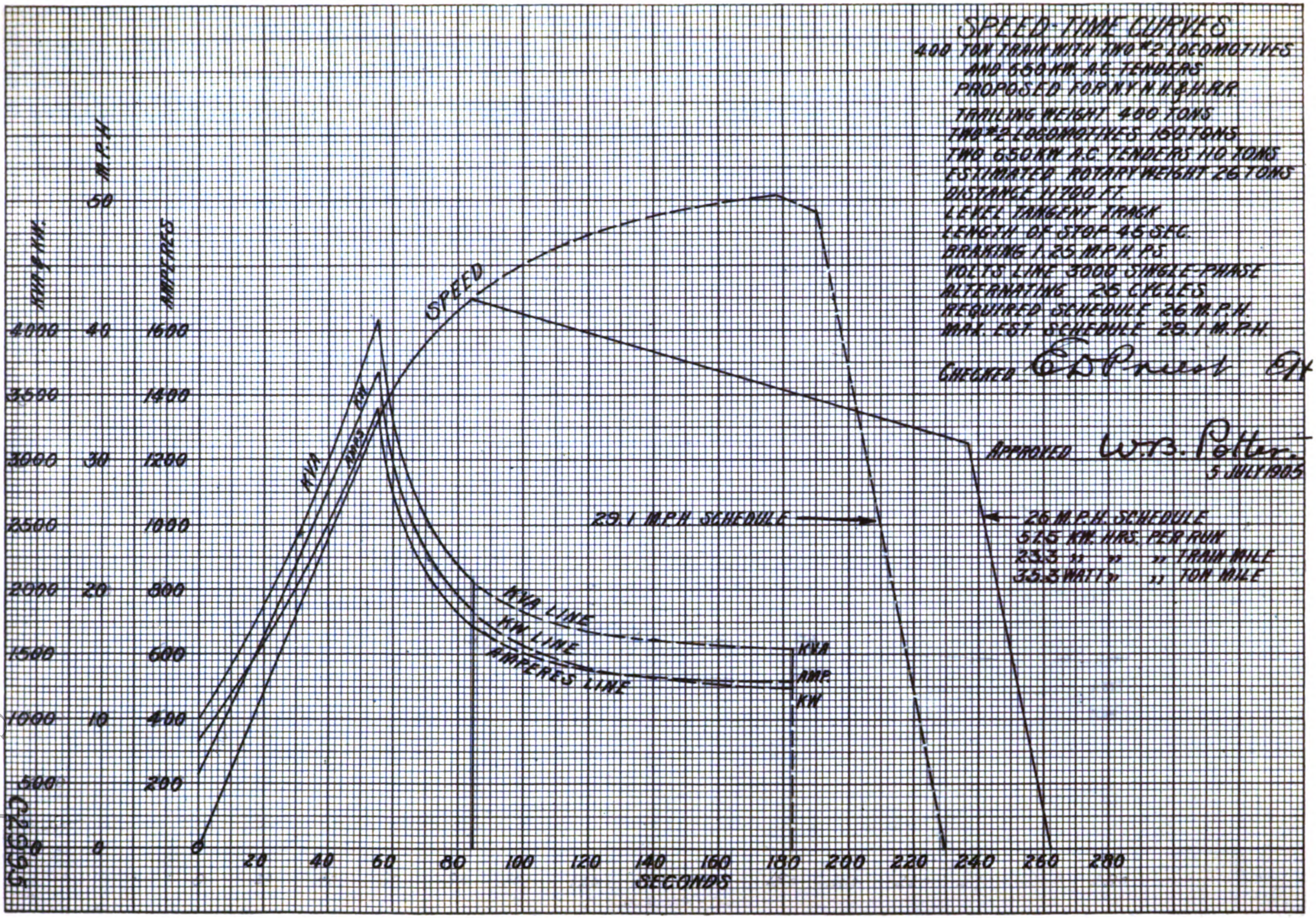

SPEED-TIME CURVES
600 TON TRAIN WITH TWO #7 LOCOMOTIVES
PROPOSED FOR N.Y.N.H.&H.R.R.
TRAILING WEIGHT 600 TONS
TWO #7 LOCOMOTIVES 240 TONS
ESTIMATED ROTARY WEIGHT 58.9 TONS
DISTANCE 11700 FT.
TANGENT LEVEL TRACK
LENGTH OF STOP 45 SEC
BRAKING 1.25 M.P.H.P.S.
VOLTS LINE 3000 SINGLE PHASE
ALTERNATING 12.5 CYCLES
REQUIRED SCHEDULE 26 M.P.H.
MAX. EST. SCHEDULE 27.7 M.P.H.
CHECKED E D Priest Eng
APPROVED W. B. Potter
5 JULY 1905
26 M.P.H. SCHEDULE
70.7 KW. HRS. PER RUN
32.1 " " " TRAIN MILE
38.2 WATT " " TON MILE
27.7 M.P.H. SCHEDULE
SPEED
KVA LINE
KW. LINE
AMPERES LINE
KVA
AMPS
KW
KVA & KW.
M.P.H
AMPERES
SECONDS
C-2983

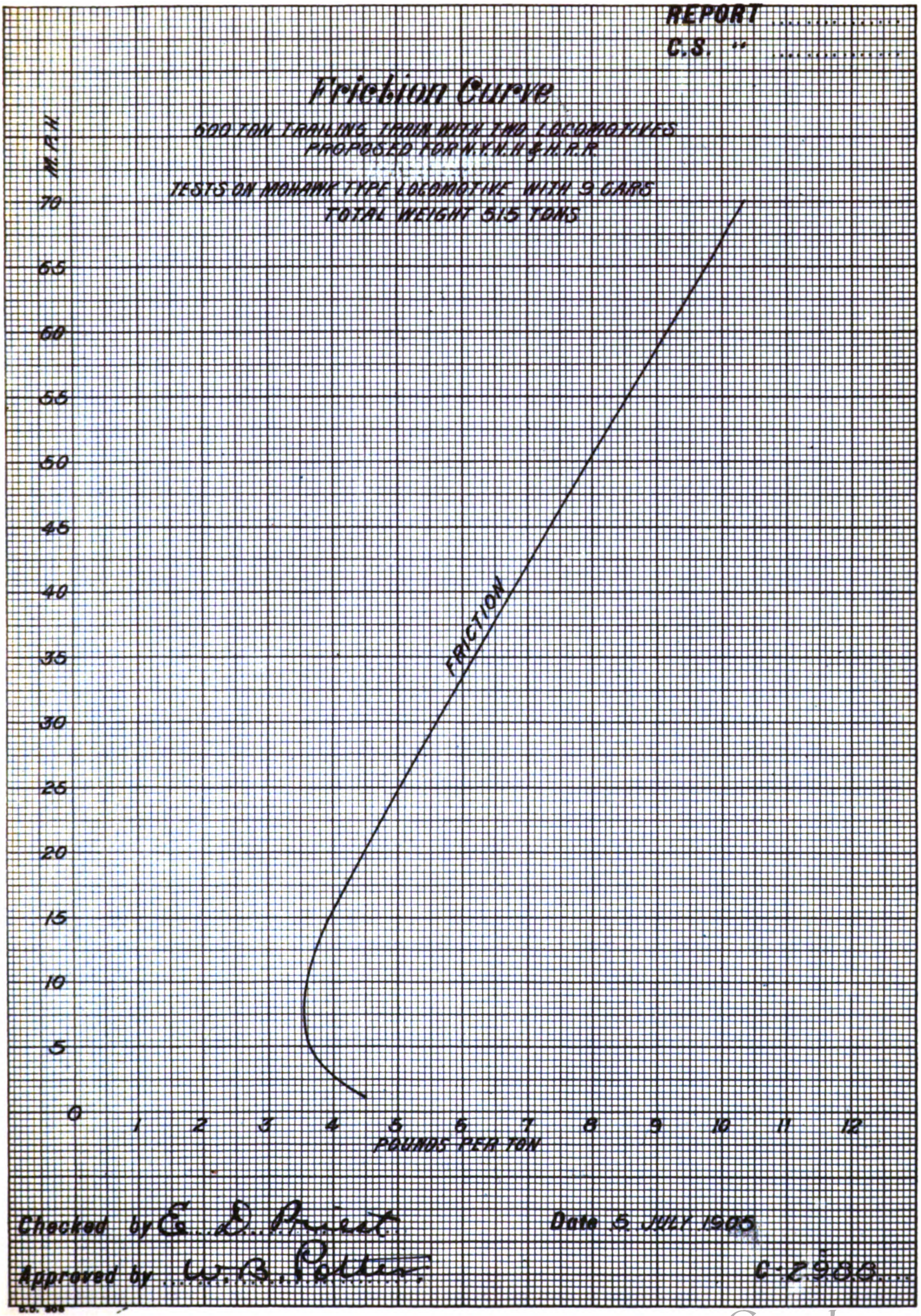

SPEED-TIME CURVES
400 TON TRAIN WITH 2 #7 LOCOMOTIVES
PROPOSED FOR N.Y.N.H.&H.R.R.
TRAILING WEIGHT 400 TONS
TWO #7 LOCOMOTIVES 240 TONS
ESTIMATED ROTARY WEIGHT 51.2 TONS.
DISTANCE 11700 FT.
TANGENT LEVEL TRACK
LENGTH OF STOP 45 SEC.
BRAKING 1.25 M.P.H. P.S.
VOLTS LINE 3000 SINGLE-PHASE
ALTERNATING 12.5 CYCLES
REQUIRED SCHEDULE 26 M.P.H.
MAX. EST. SCHEDULE 29.6 M.P.H.
CHECKED E D Priest Eng
APPROVED W. B. Potter
5 JULY 1905
29.6 M.P.H. SCHEDULE
26 M.P.H. SCHEDULE
49.4 K.W. HRS. PER RUN
22.4 " " " TRAIN MILE
35 WATT " " TON MILE
SPEED
KVA
AMPS.
K.W.
KVA LINE
KW LINE
AMPERES LINE
KVA & KW.
M.P.H.
AMPERES
4000
3500
3000
2500
2000
1500
1000
500
60
50
40
30
20
10
1400
1200
1000
800
600
400
200
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
SECONDS
C-2984

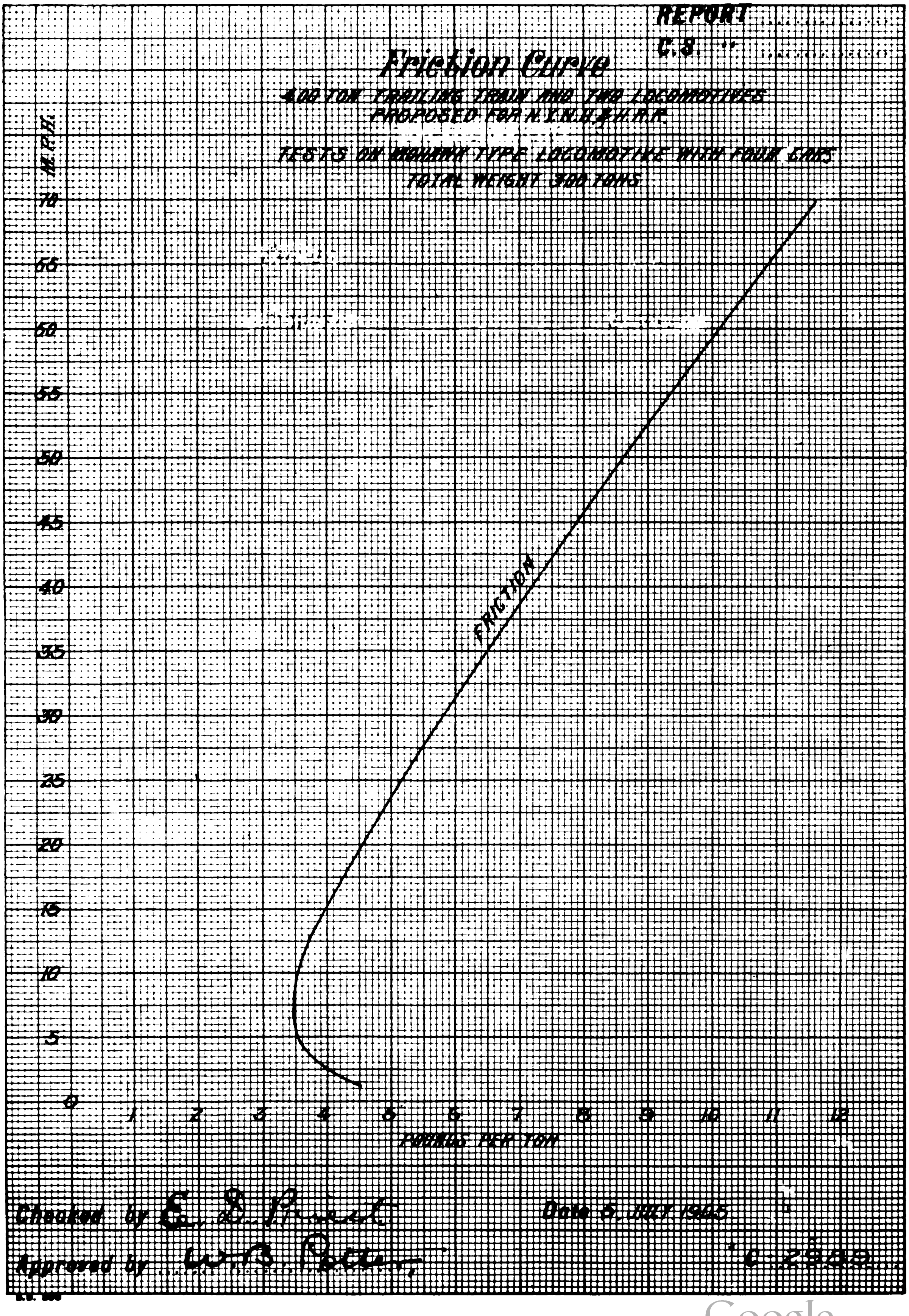

SPEED-TIME CURVES
600 TON TRAIN WITH TWO #1 LOCOMOTIVES
AND 900 KW. A.C. TENDERS
PROPOSED FOR N.Y.N.H.&H.R.R.
TRAILING WEIGHT 600 TONS
TWO #1 LOCOMOTIVES 200 TONS
TWO 900 KW. A.C. TENDERS 140 TONS
ESTIMATED ROTARY WEIGHT 35 TONS
DISTANCE 11700 FT.
LEVEL TANGENT TRACK
LENGTH OF STOP 45 SEC.
BRAKING 1.25 M.P.H. P.S.
VOLTS LINE 3000 SINGLE-PHASE
ALTERNATING 25 CYCLES
REQUIRED SCHEDULE 26 M.P.H.
MAX. EST. SCHEDULE 29.1 M.P.H.
CHECKED E.D. Priest. Eng
APPROVED W.B. Potter
5 JULY 1906
26 M.P.H. SCHEDULE
74 KW. HRS. PER RUN
33.5 " " " TRAIN MILE
35.6 W " " TON MILE
29.1 M.P.H. SCHEDULE
SPEED
KVA
KW
AMP
KVA LINE
KW LINE
AMPERES LINE
KVA & KW
M.P.H.
AMPERES
SECONDS
G 2992

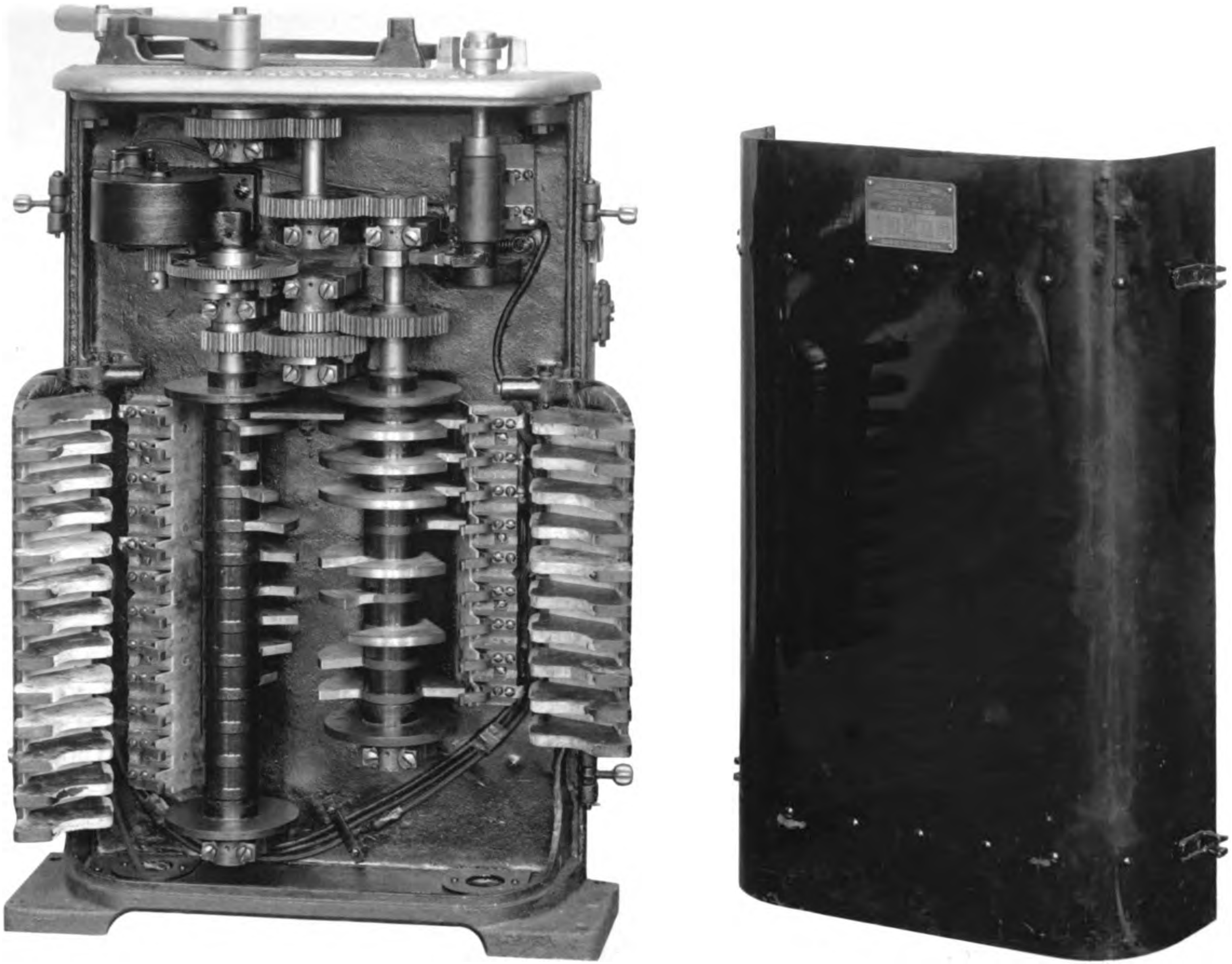

SPEED-TIME CURVES
400 TON TRAIN WITH TWO #1 LOCOMOTIVES
AND 900 KW. A.C. TENDERS
PROPOSED FOR N.Y.N.H.&H.R.R.
TRAILING WEIGHT 400 TONS
TWO #1 LOCOMOTIVES 200 TONS
TWO 900 KW. A.C. TENDERS 140 TONS
ESTIMATED ROTARY WEIGHT 29 TONS
DISTANCE 11700 FT.
LEVEL TANGENT TRACK
LENGTH OF STOP 45 SEC.
BRAKING 1.25 M.P.H. P.S.
VOLTS LINE 3000 SINGLE-PHASE
ALTERNATING 25 CYCLES
REQUIRED SCHEDULE 26 M.P.H.
MAX. EST. SCHEDULE 30.7 M.P.H.
CHECKED E.D. Priest Est.
APPROVED W.B. Potter
5 JULY 1905
KW. & KVA
M.P.H.
AMPERES
SPEED
KVA
KW
AMP
KVA LINE
KW. LINE
AMPERES LINE
30.7 M.P.H. SCHEDULE
26 M.P.H. SCHEDULE
55.4 KW. HRS. PER RUN
25.1 " " " TRAIN MILE
34 WATT " " TON MILE
SECONDS
C 2993


SPEED TIME CURVES
600 TON TRAIN WITH TWO #2 LOCOMOTIVES
AND 650 K.W. A.C. TENDERS
PROPOSED FOR N.Y.N.H.&H.R.R.
TRAILING WEIGHT 600 TONS
TWO #2 LOCOMOTIVES 150 TONS
TWO 650 K.W. A.C. TENDERS 110 TONS
ESTIMATED ROTARY WEIGHT 32 TONS
DISTANCE 11700 F.T.
LEVEL TANGENT TRACK
LENGTH OF STOP 45 SEC.
BRAKING 1.25 M.P.H. P.S.
VOLTS LINE 3000 SINGLE-PHASE
ALTERNATING 25 CYCLES
REQUIRED SCHEDULE 26 M.P.H.
MAX. EST. SCHEDULE 27.6 M.P.H.
CHECKED E D Priest Eng
APPROVED W. B. Potter
5 JULY 1905
27.5 M.P.H. SCHEDULE
26 M.P.H. SCHEDULE
71 KW. HRS PER RUN
32.1 " " " TRAIN MILE
37.3 W. " " TON MILE
SPEED
KVA
AMP
KW
AMPERES LINE
KVA LINE
KW. LINE
KVA & KW
M.P.H.
AMPERES
SECONDS
C-2994

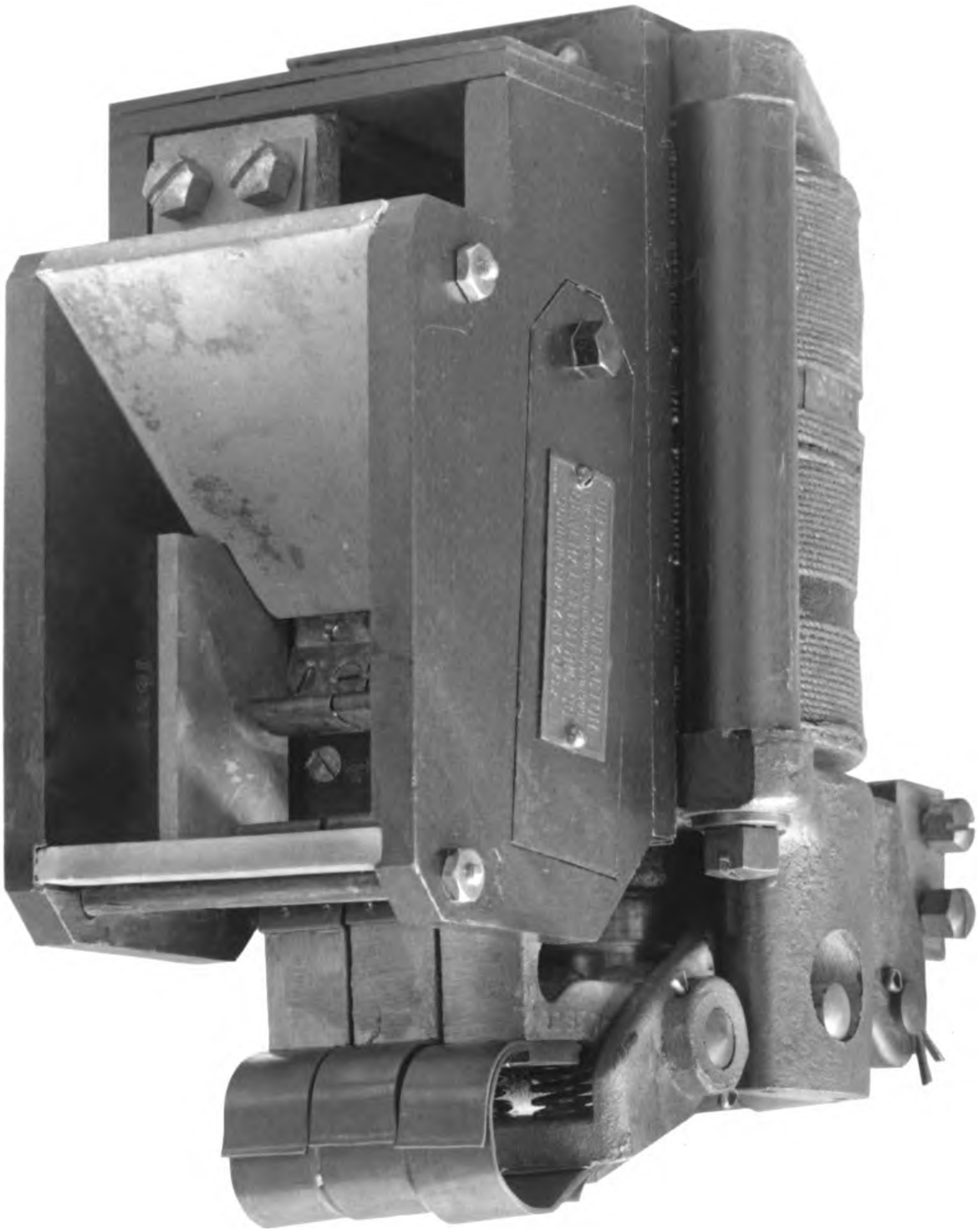

SPEED-TIME CURVES
400 TON TRAIN WITH TWO #2 LOCOMOTIVES
AND 650 KW. A.C. TENDERS
PROPOSED FOR N.Y. N.H. & H. R.R.
TRAILING WEIGHT 400 TONS
TWO #2 LOCOMOTIVES 150 TONS
TWO 650 KW A.C. TENDERS 110 TONS
ESTIMATED ROTARY WEIGHT 26 TONS
DISTANCE 11700 FT.
LEVEL TANGENT TRACK
LENGTH OF STOP 45 SEC.
BRAKING 1.25 M.P.H. P.S.
VOLTS LINE 3000 SINGLE-PHASE
ALTERNATING 25 CYCLES
REQUIRED SCHEDULE 26 M.P.H.
MAX. EST. SCHEDULE 29.1 M.P.H.
CHECKED E D Priest
APPROVED W. B. Potter
5 JULY 1905
29.1 M.P.H. SCHEDULE
26 M.P.H. SCHEDULE
51.5 KW. HRS. PER RUN
23.3 " " " TRAIN MILE
35.3 WATT " " TON MILE
SPEED
KVA
AMPS
KW
KVA LINE
KW LINE
AMPERES LINE
KVA
AMP
KW
KVA & KW.
M.P.H.
AMPERES
4000
3500
3000
2500
2000
1500
1000
500
50
40
30
20
10
0
1600
1400
1200
1000
800
600
400
200
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
SECONDS
C2995


REPORT
C.S.
Friction Curve
600 TON TRAILING TRAIN WITH TWO LOCOMOTIVES
PROPOSED FOR N.Y.N.H.&H.R.R.
TESTS ON MOHAWK TYPE LOCOMOTIVE WITH 9 CARS
TOTAL WEIGHT 515 TONS
M.P.H.
70
65
60
55
50
45
40
35
30
25
20
15
10
5
0
1
2
3
4
5
6
7
8
9
10
11
12
FRICTION
POUNDS PER TON
Checked by E. D. Priest
Date 5 JULY 1905
Approved by W. B. Potter
C-2988

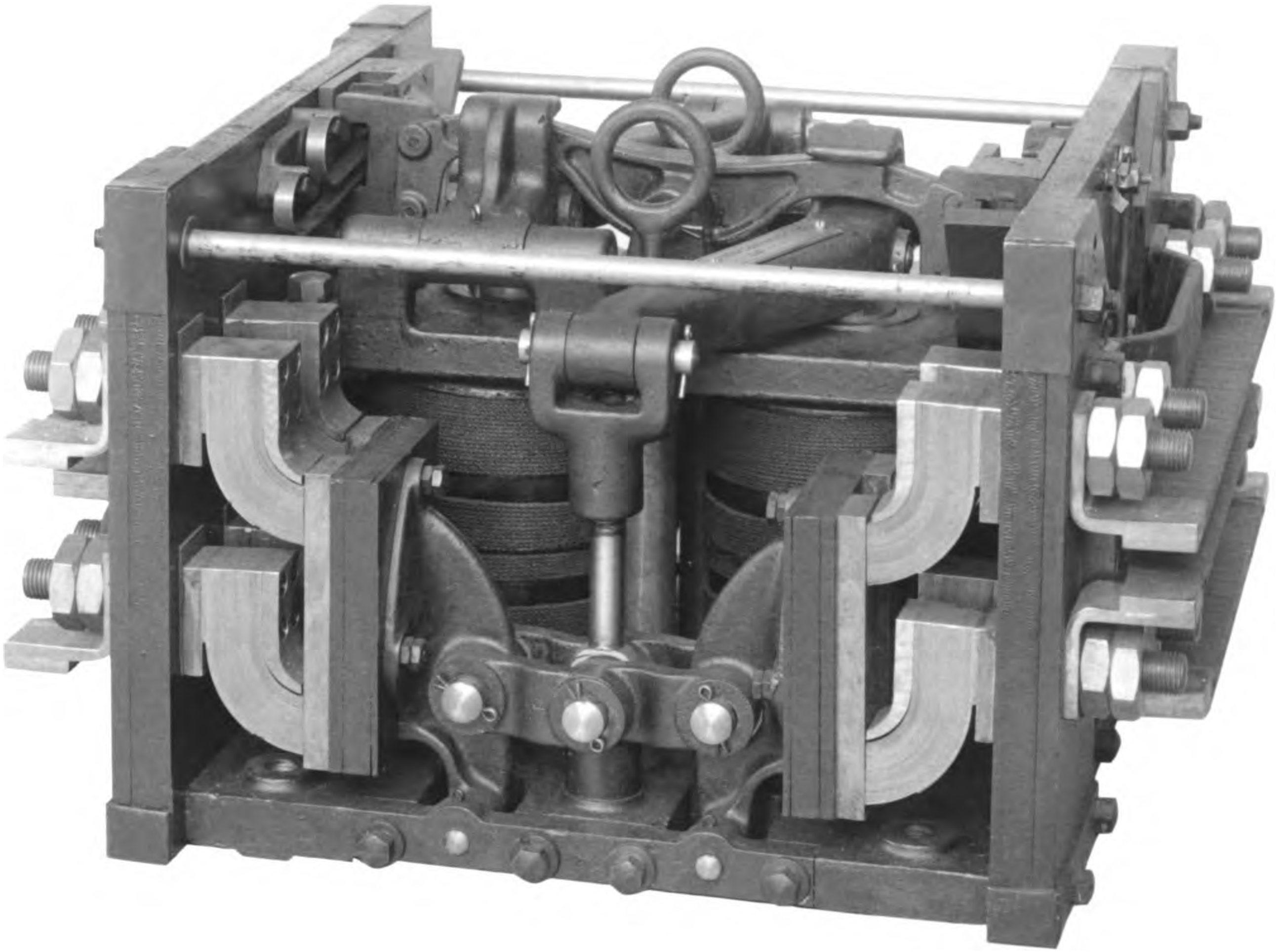

REPORT
C.8
Friction Curve
400 TON TRAILING TRAIN AND TWO LOCOMOTIVES
PROPOSED FOR N.Y.N.H.&H.R.R.
TESTS ON MOHAWK TYPE LOCOMOTIVE WITH FOUR CARS
TOTAL WEIGHT 300 TONS
M.P.H.
70
65
60
55
50
45
40
35
30
25
20
15
10
5
0
1
2
3
4
5
6
7
8
9
10
11
12
FRICTION
POUNDS PER TON
Checked by
Date 5. JULY 1905
Approved by
C 2983



301547 MASTER CONTROLLER.
FRONT VIEW.

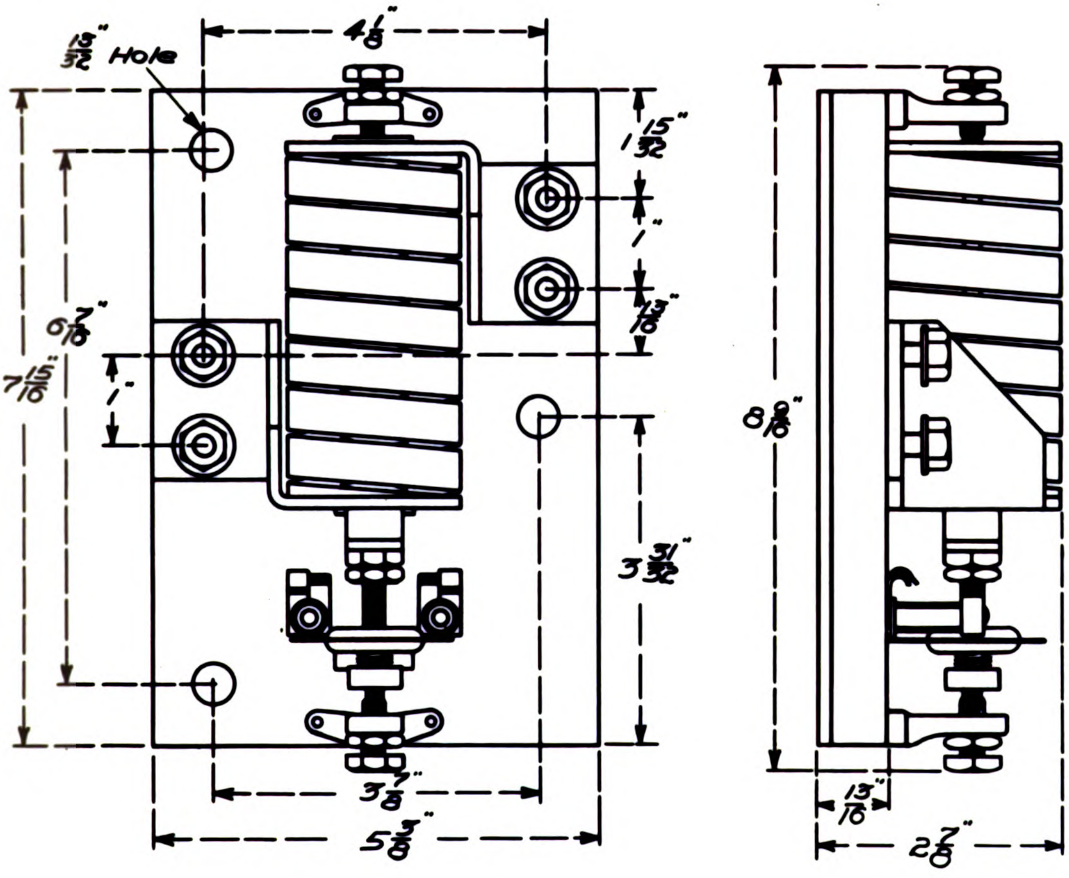


302022 DB-51-A1 CONTACTOR.



301954 DE-40 REVERSER.

Dimensions of D B-111 Relay Form A

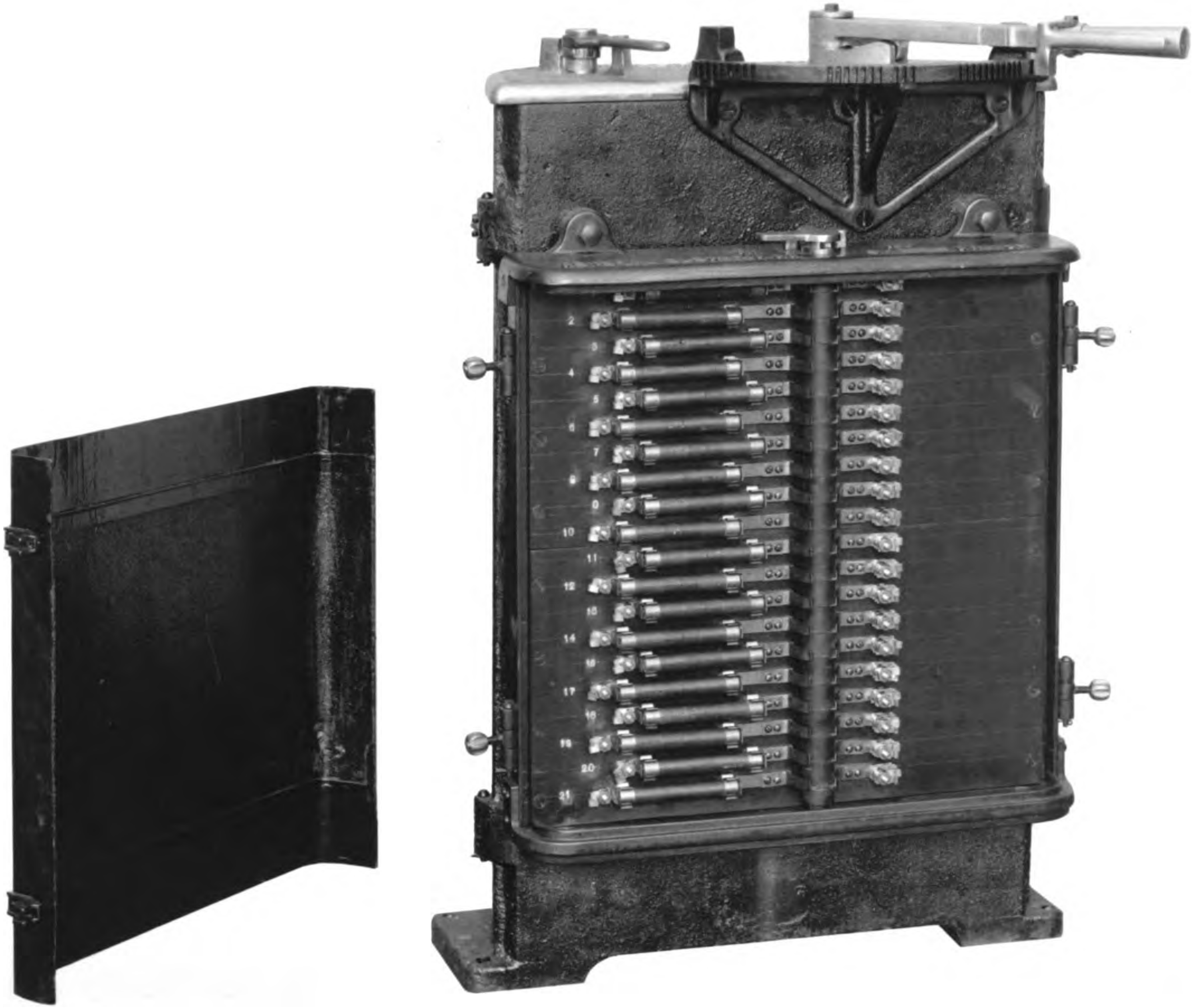


Checked

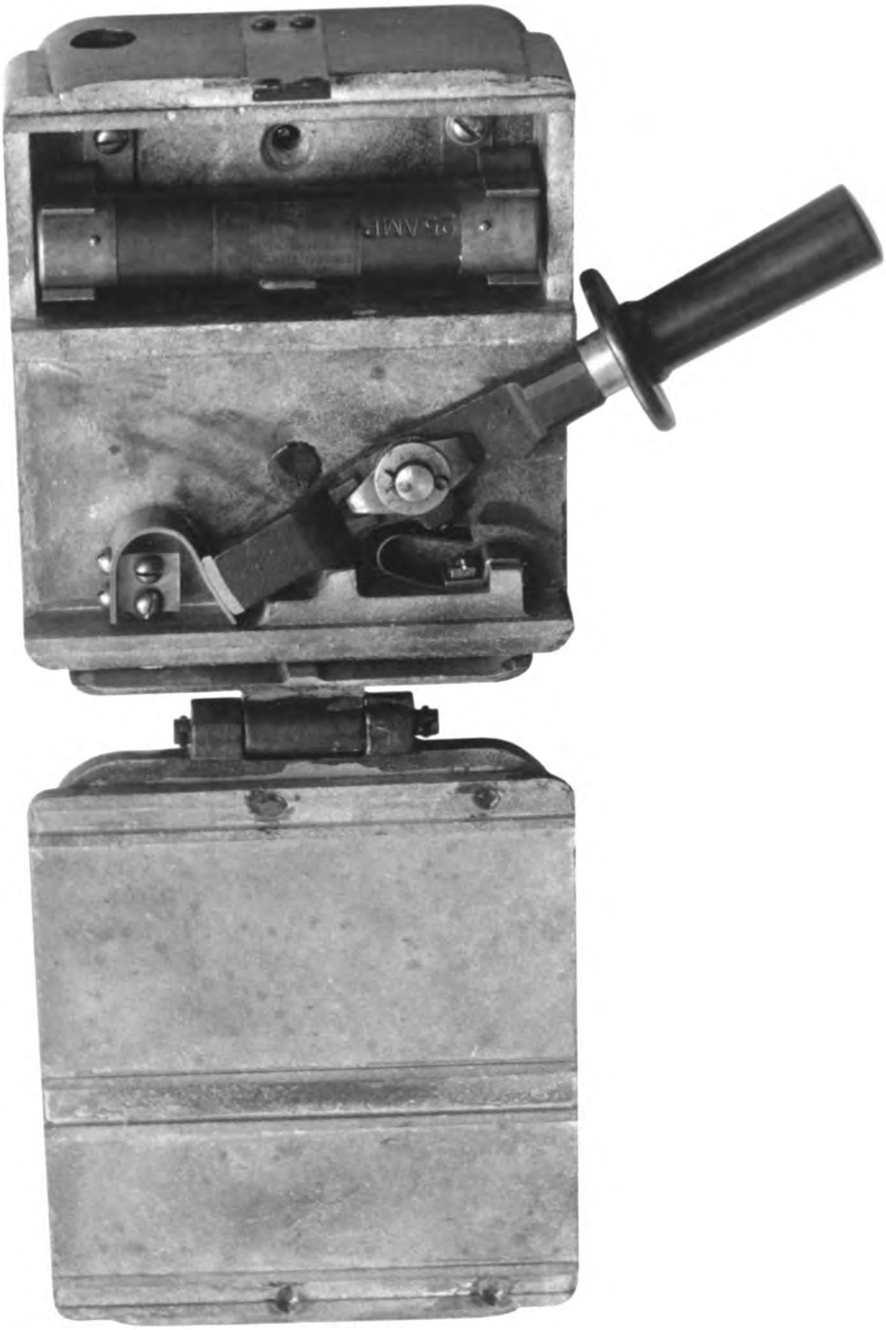
Approved

Engineering Dept.

8 June 1905 General Electric Company D.S. 5962

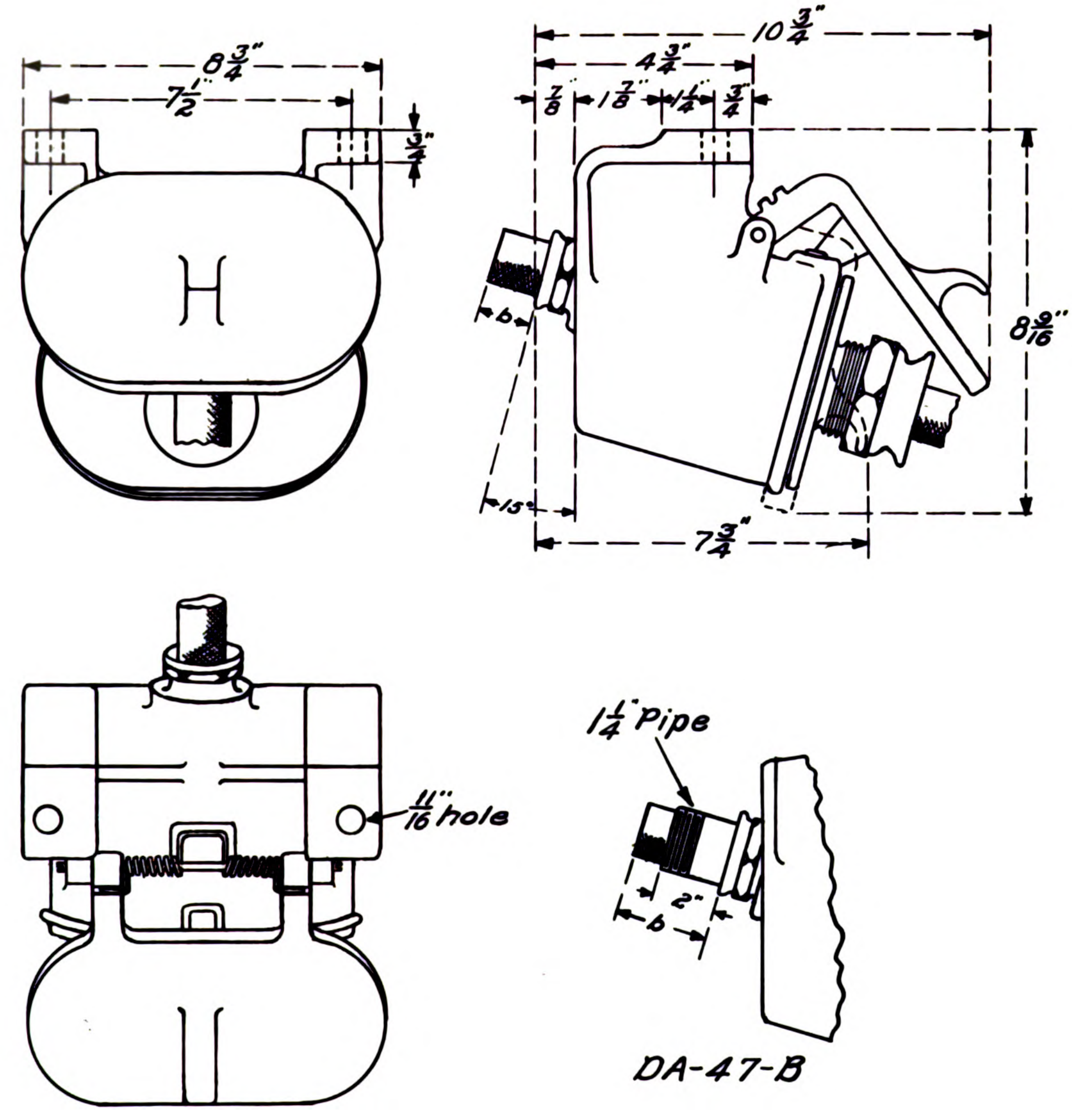


301548 MASTER CONTROLLER,
BACK VIEW, SHOWING CUTOUT SWITCH.



300-26 MS-40-A SWITCH.

Dimensions of DA-47 Coupler Sockets Forms A and B and DC33 Plug Form A



DA-47-B

Checked A.C.P.

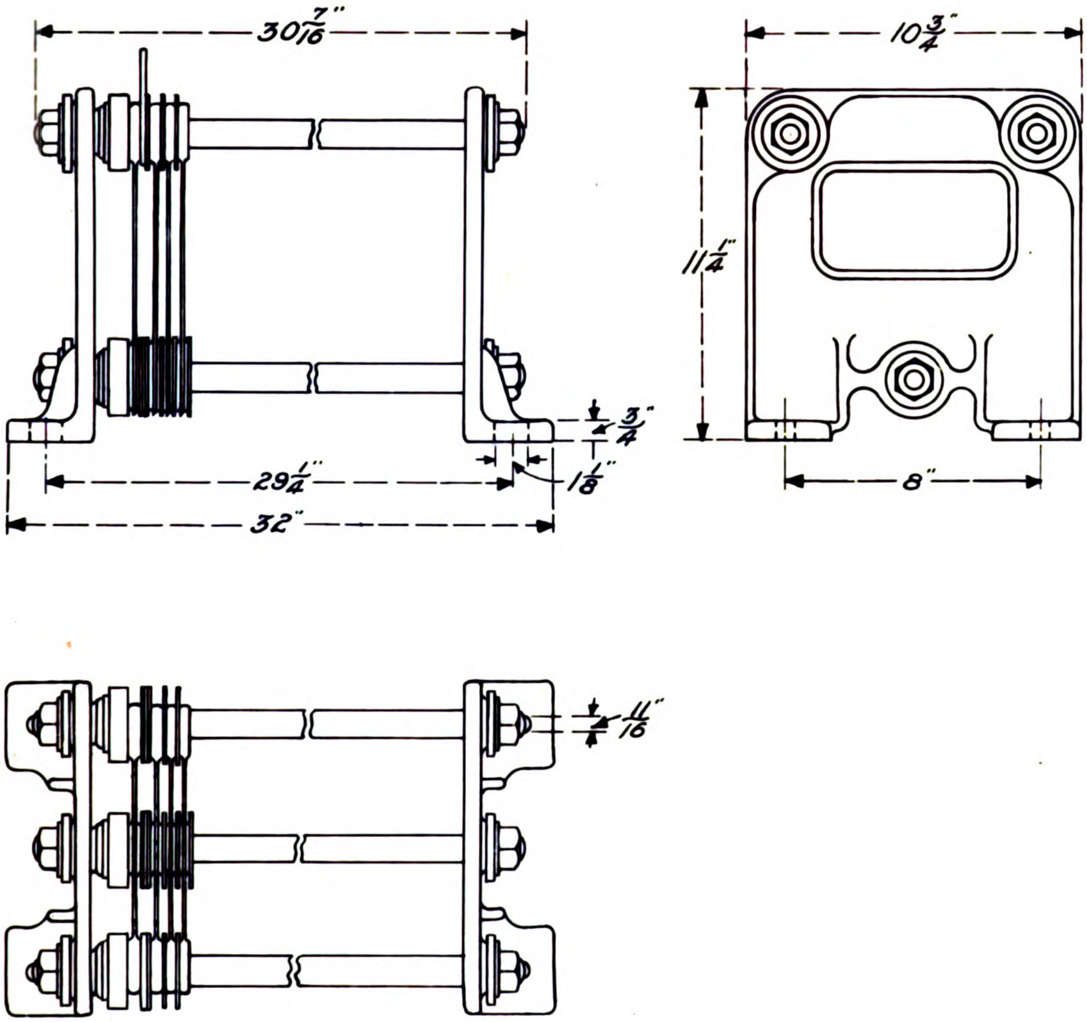
Approved

Engineering Dept.

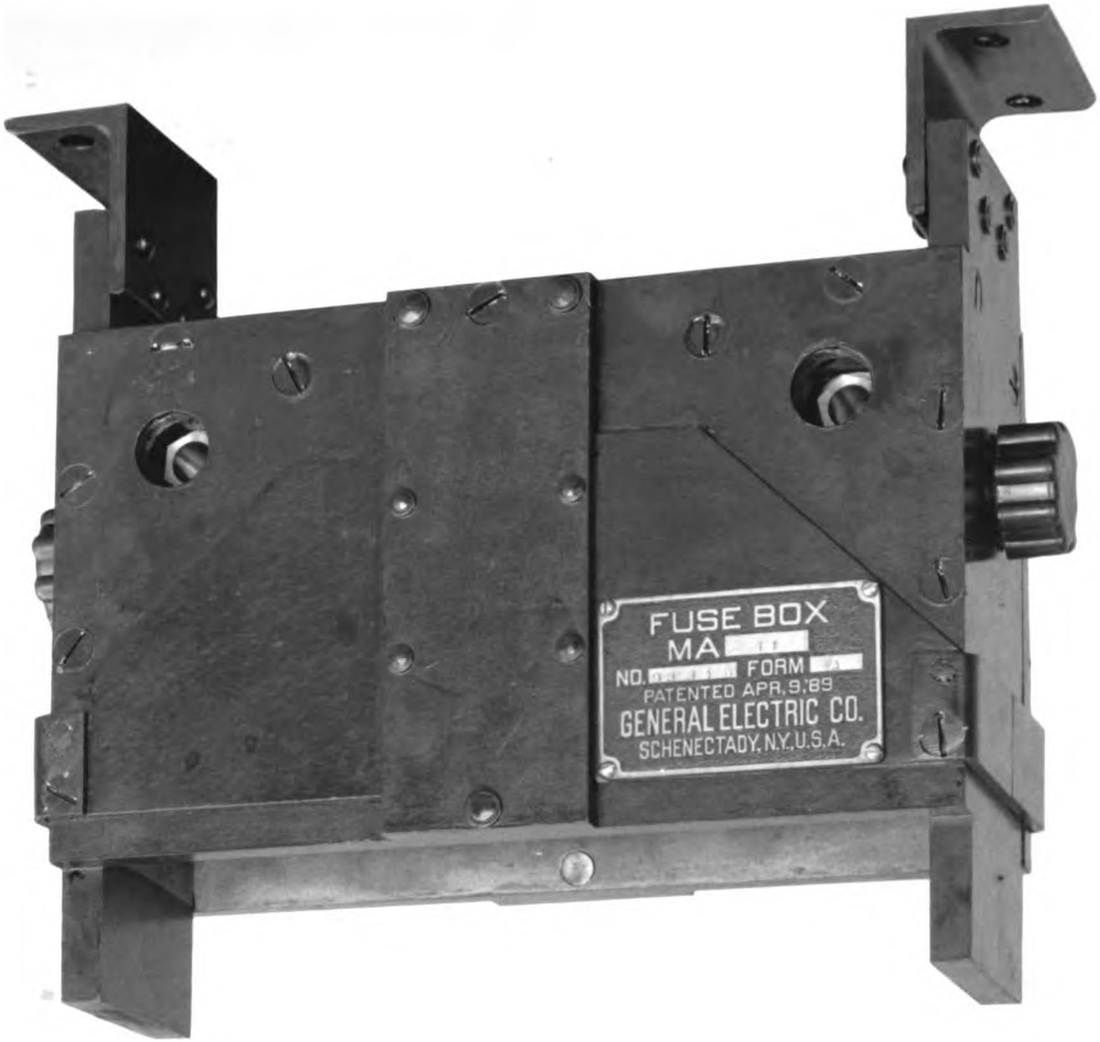
14 June, 1905 General Electric Company D.S. 6234

J.J.R

Dimensions of Type C G Rheostat Form F

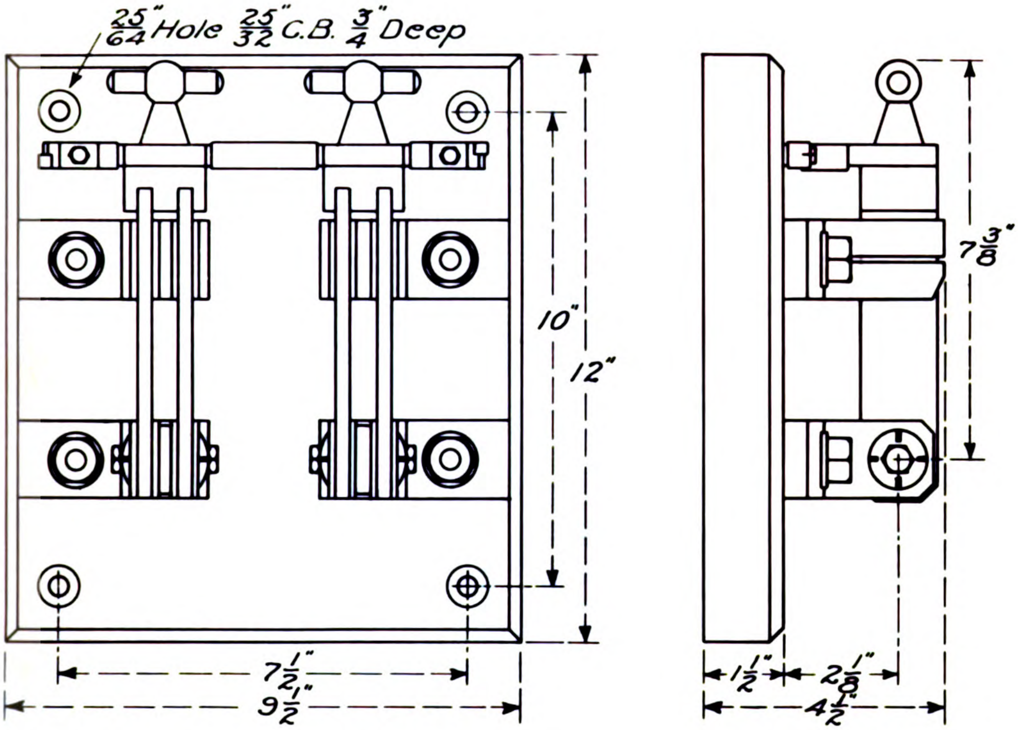


Checked W. C. Yates
C. a. J. Engineering Dept.
1 May 1905 General Electric Company D.S. 5896
J.J.R.



301125 MA-11-A FUSE BOX.

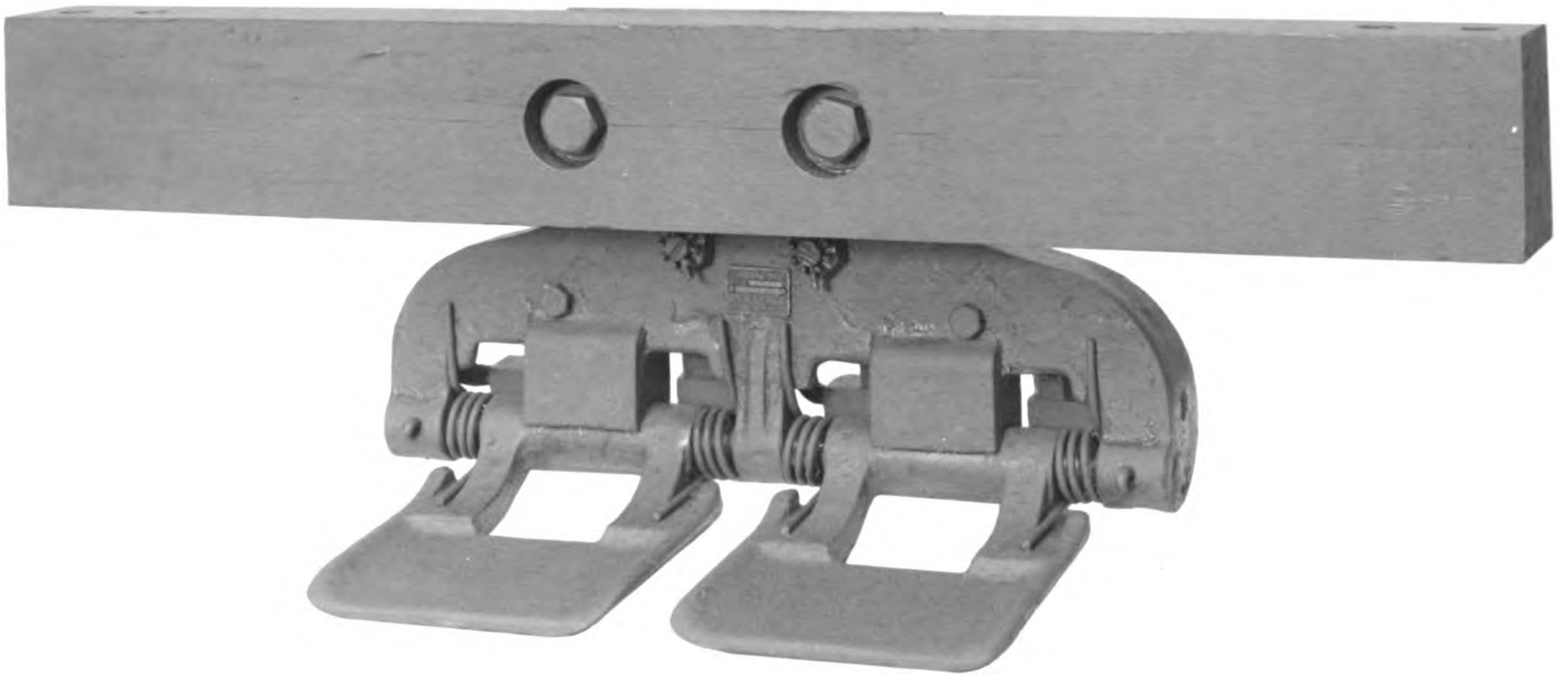
Dimensions of DH 12 Cut-out Switch Form A



Checked ______

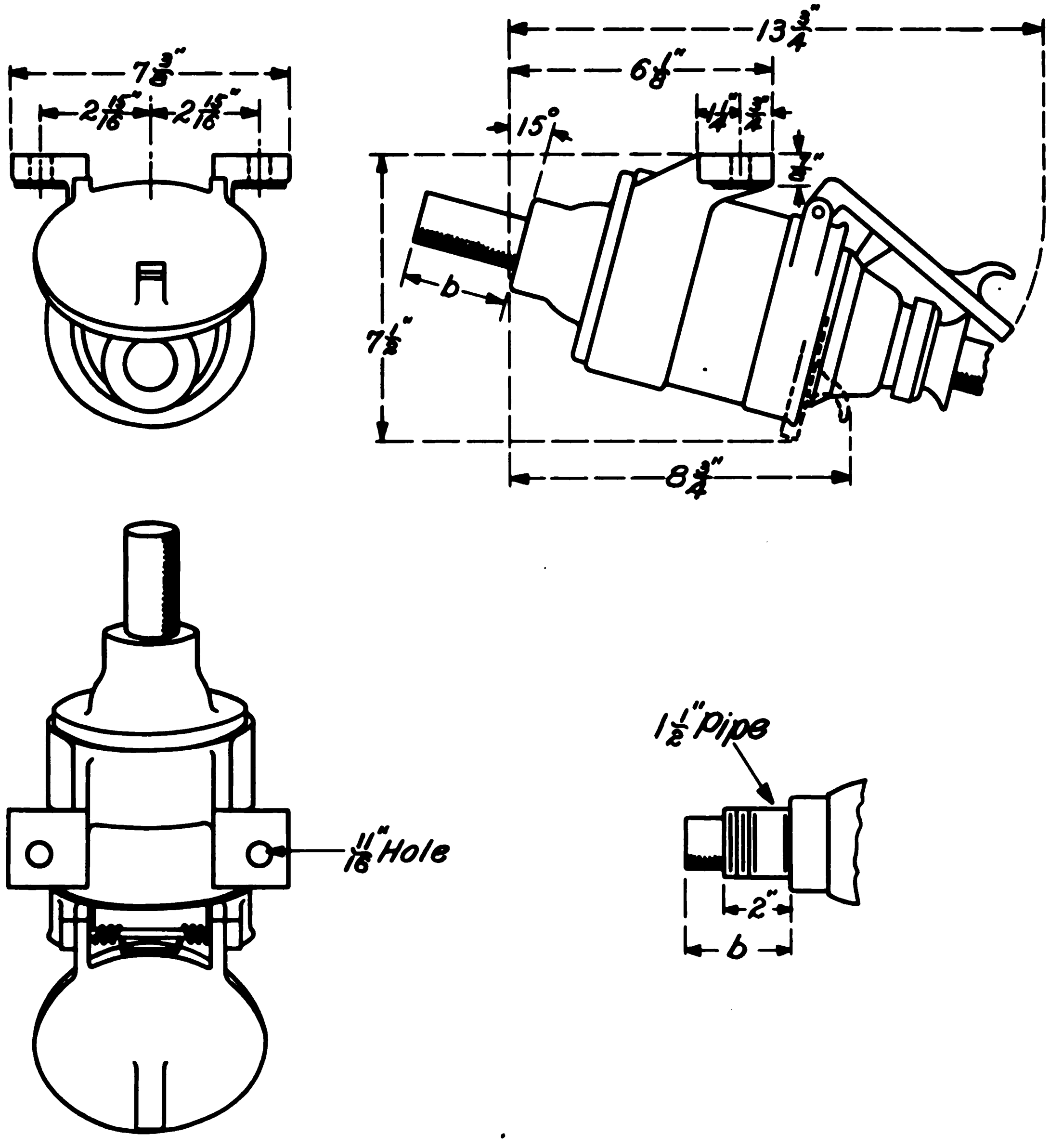
Engineering Dept.

18 Oct. 1904 General Electric Company DS 4928



301907 D.N-40-A THIRD RAIL SHOE.

Dimensions of DA-48 Coupler Sockets Forms A and B
and DC-34 Plug Form A



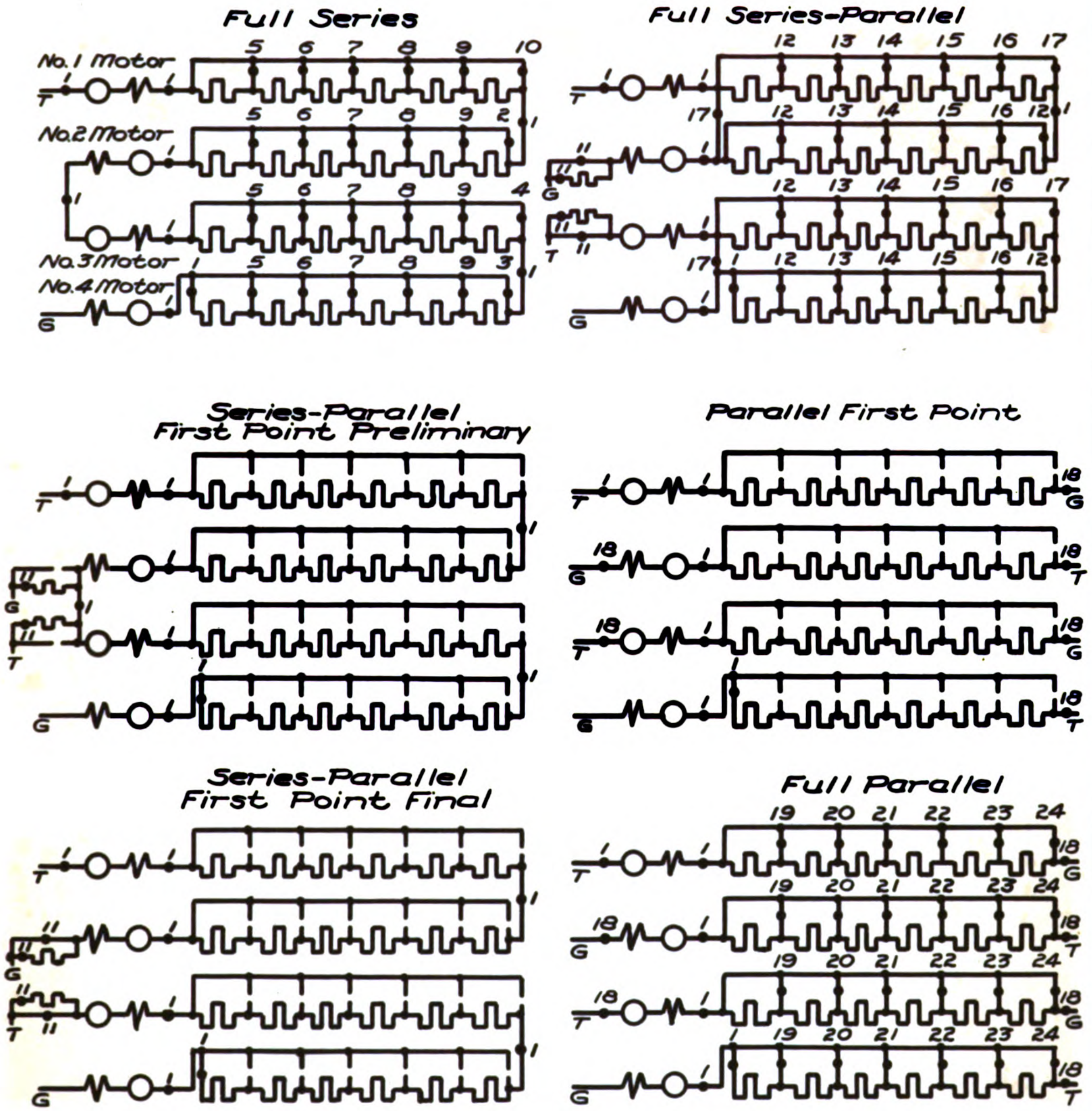
Checked H.C.P.

Approved [illegible]

Engineering Dept.

14 June 1905. General Electric Company D.S. 6233

Motor Circuits of Sprague-General Electric Multiple Unit Control
for Four Direct Current Motors for Locomotive



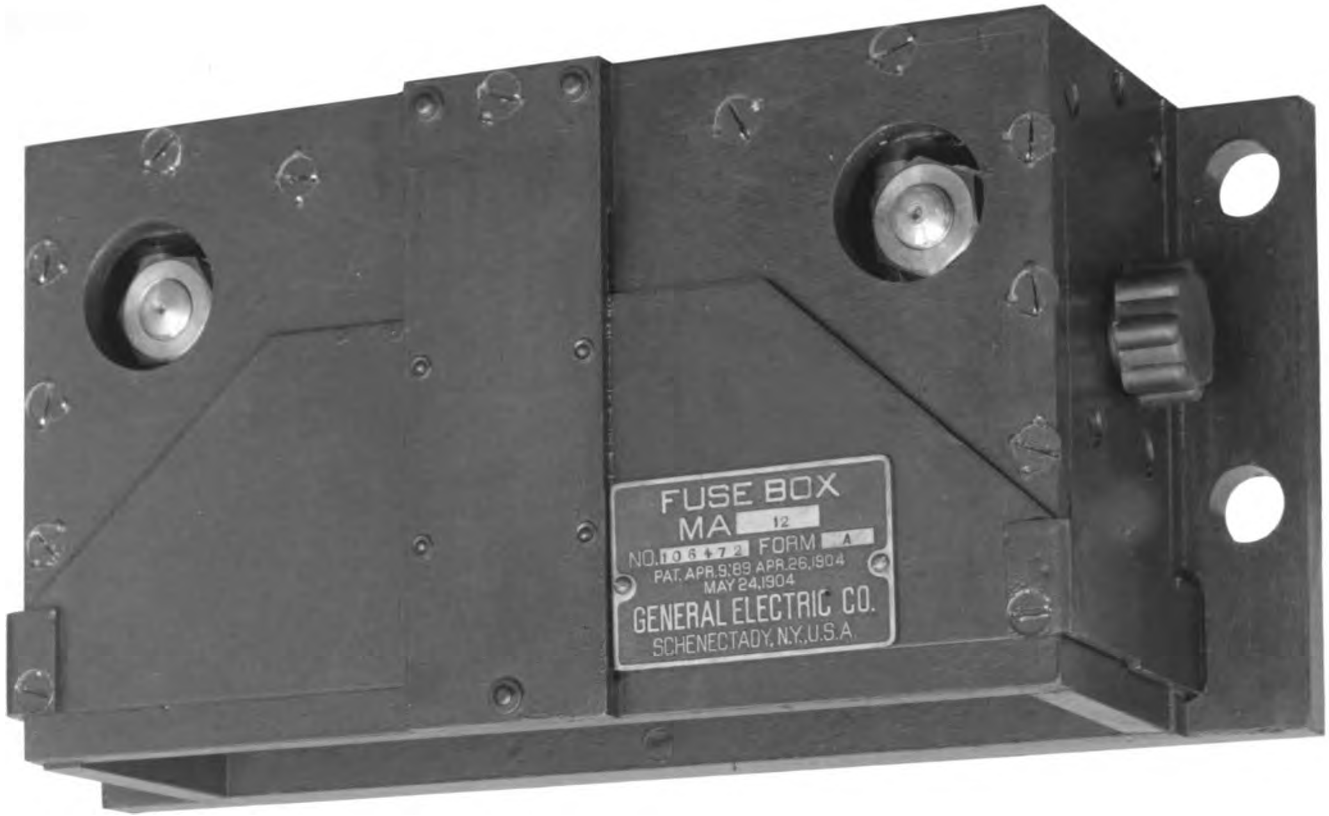
Numerials indicate the steps when Contactors are closed

Checked H.C.P.
Approved F. E. Case
14 June 1905

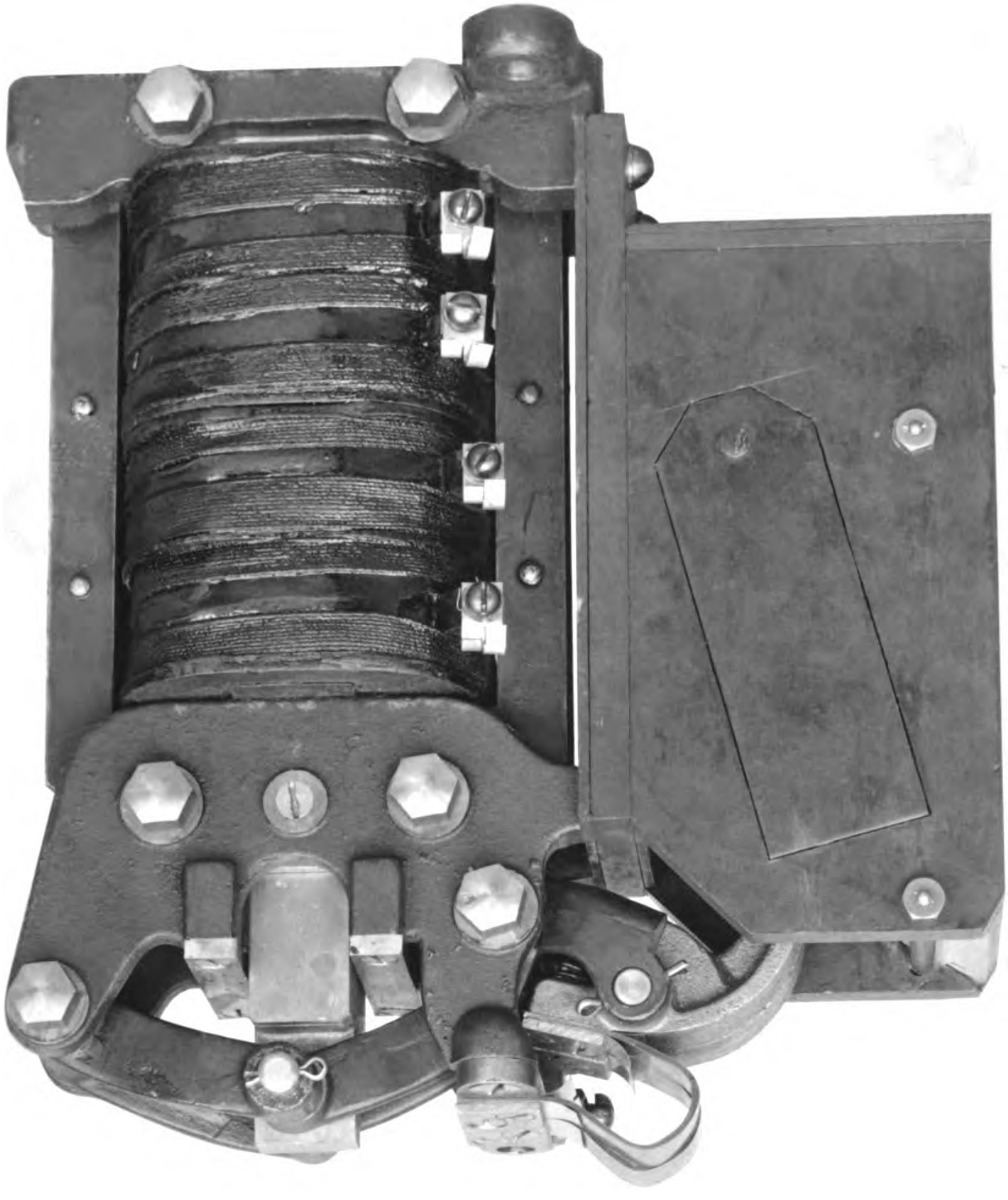
Engineering Dept.
General Electric Company

D.S. 6232

S.F.F.



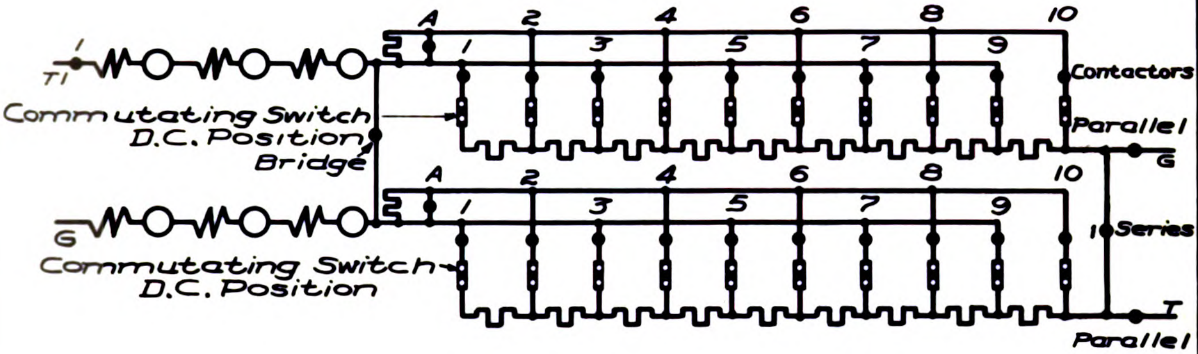
301551 - LA-12-A FUSE BOX.



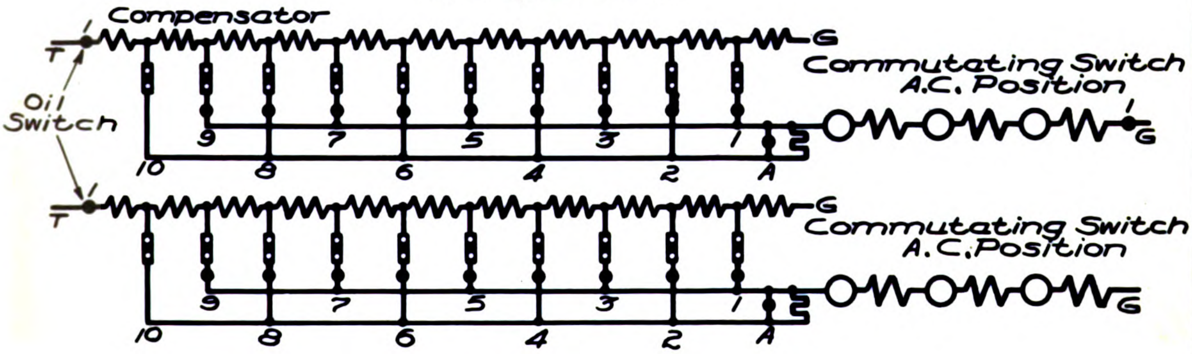
301941 DB-71-K2 CONTACTOR.

Motor Circuits for 145 Ton Locomotive with Six Motors
for Alternating and Direct Currents

D.C Operation



A.C. Operation



In D.C. operation A contactors remain closed

In A.C. operation A contactors are closed at each step to prevent short circuiting the part of the compensator cutout

Numerials indicate the steps when contactors are closed

Checked H.C.R.

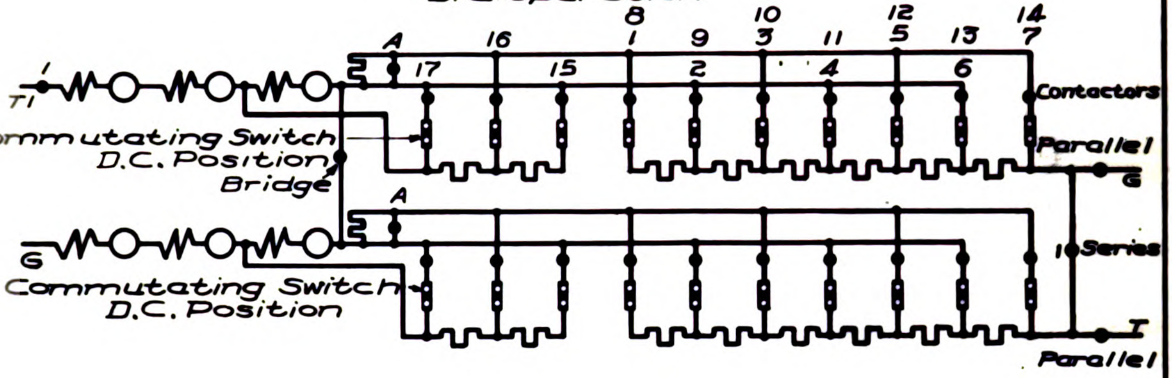
Approved F.E. Case

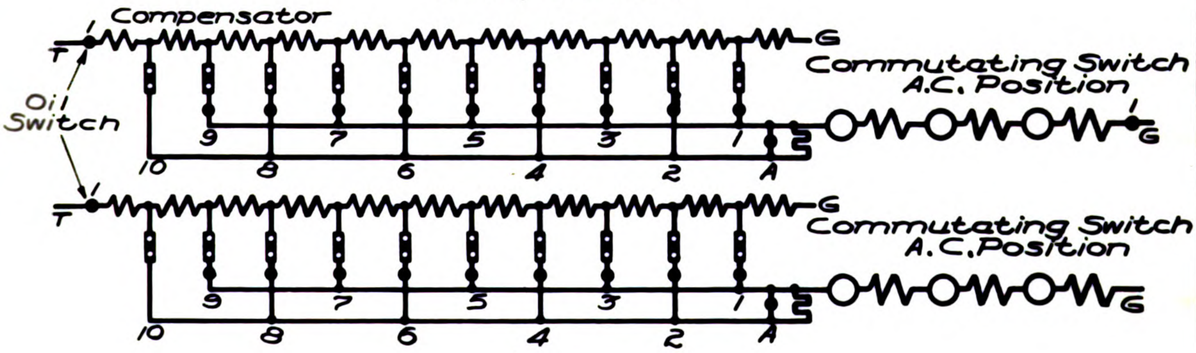
Engineering Dept.

23 June 1905 General Electric Company D.S. 6256

Motor Circuits for 145 Ton Locomotive with Six Motors for Alternating and Direct Currents

Locomotive No. 6





In D.C. operation A contactors remain closed

In A.C. operation A contactors are closed at each step to prevent short circuiting the part of the compensator cutout

Numerials indicate the steps when contactors are closed

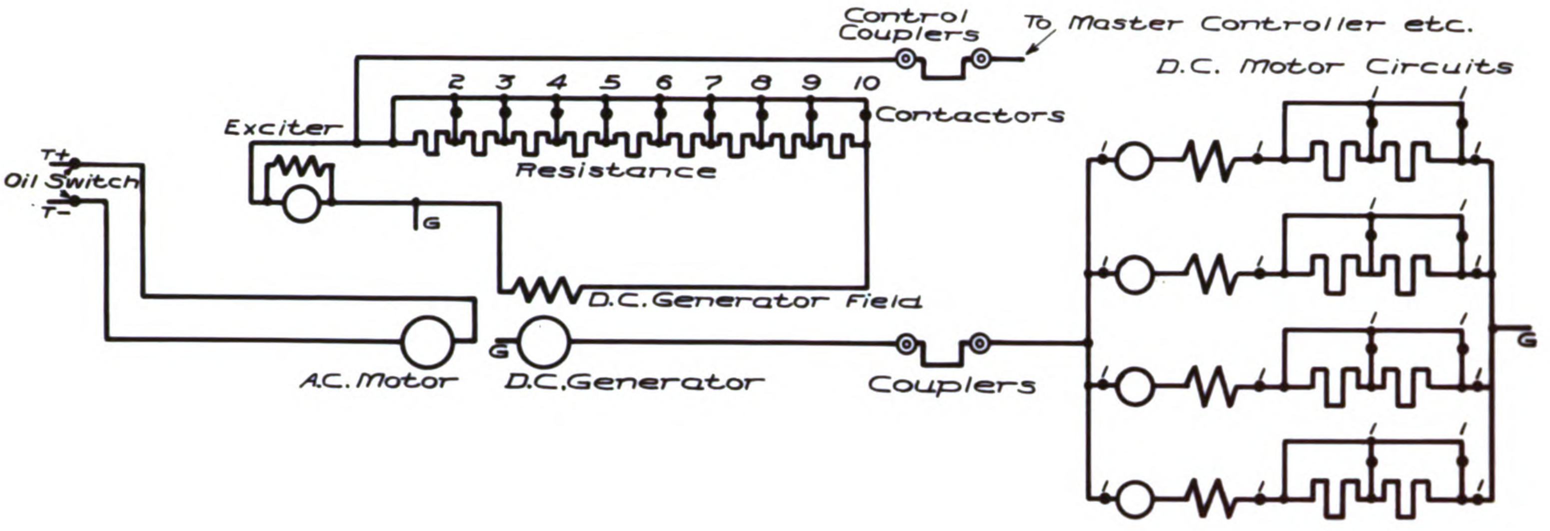
Checked H.C.P.

Approved F.E. Case

Engineering Dept.

23 June 1905 General Electric Company D.S. 6270

Connections for Motor Generator Set Carried on Tender and D.C. Motors on Locomotive



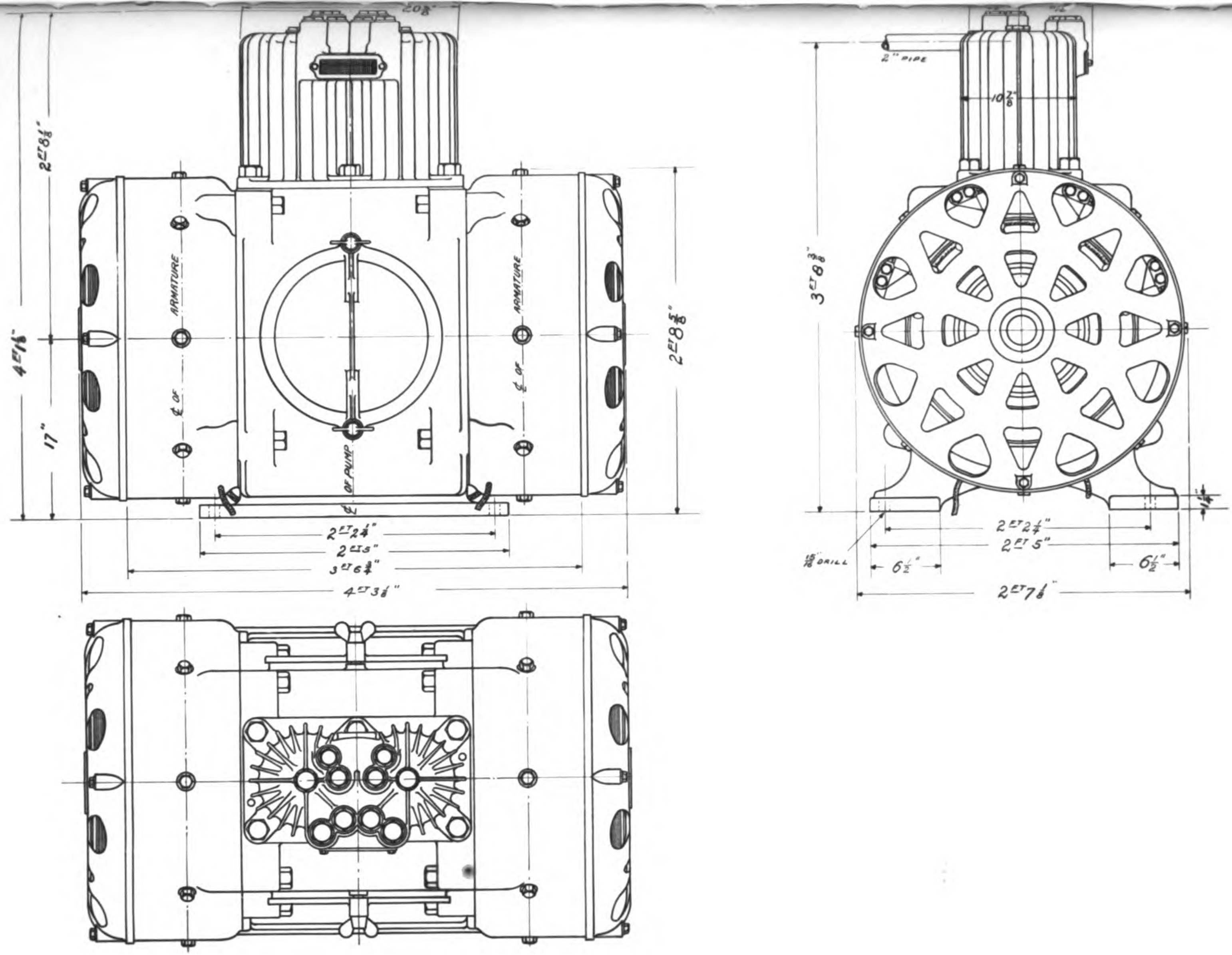
Checked F.C.P.

Approved

19 June 1905

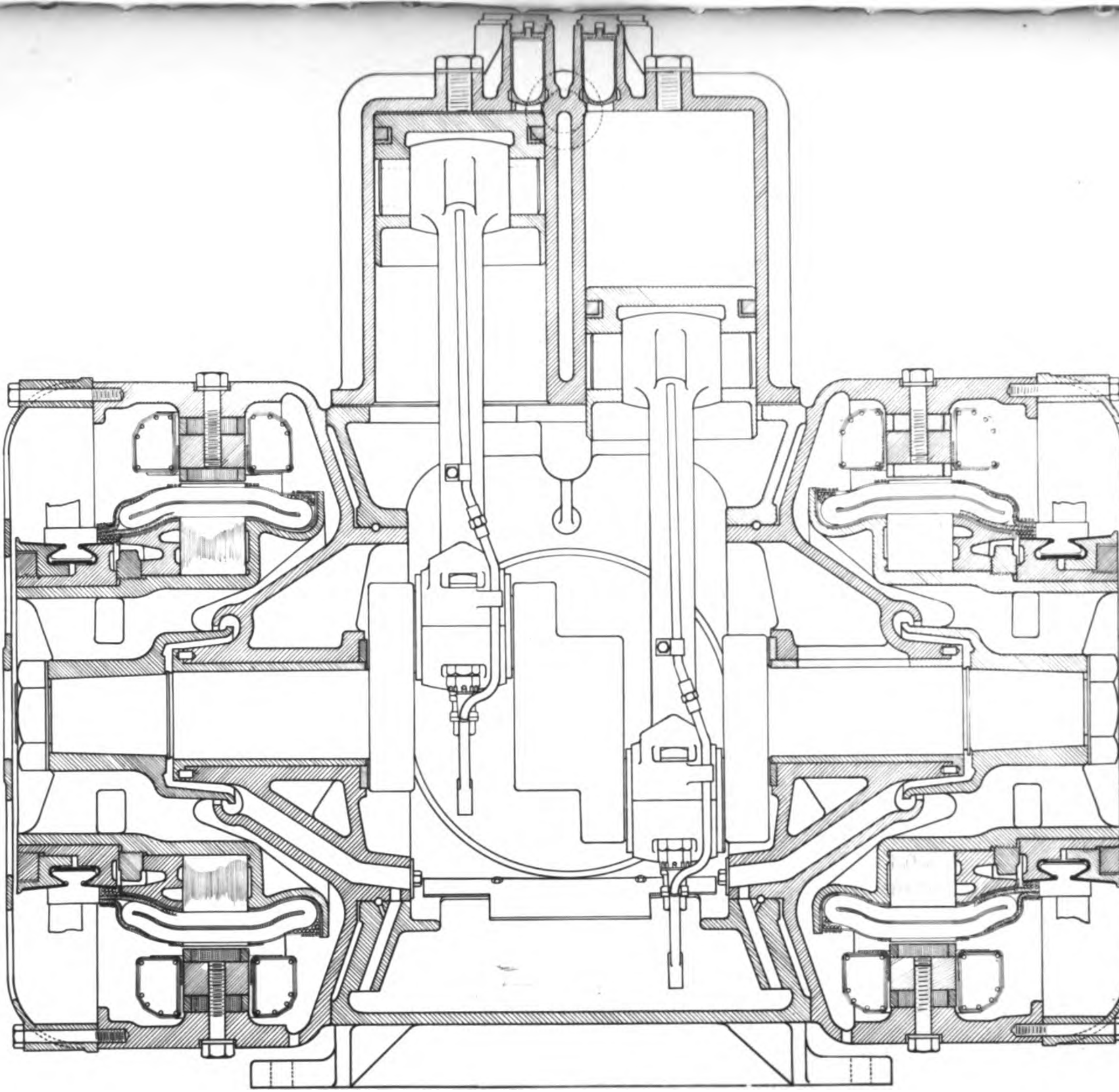
Engineering Dept.
General Electric Company

D.S. 6262



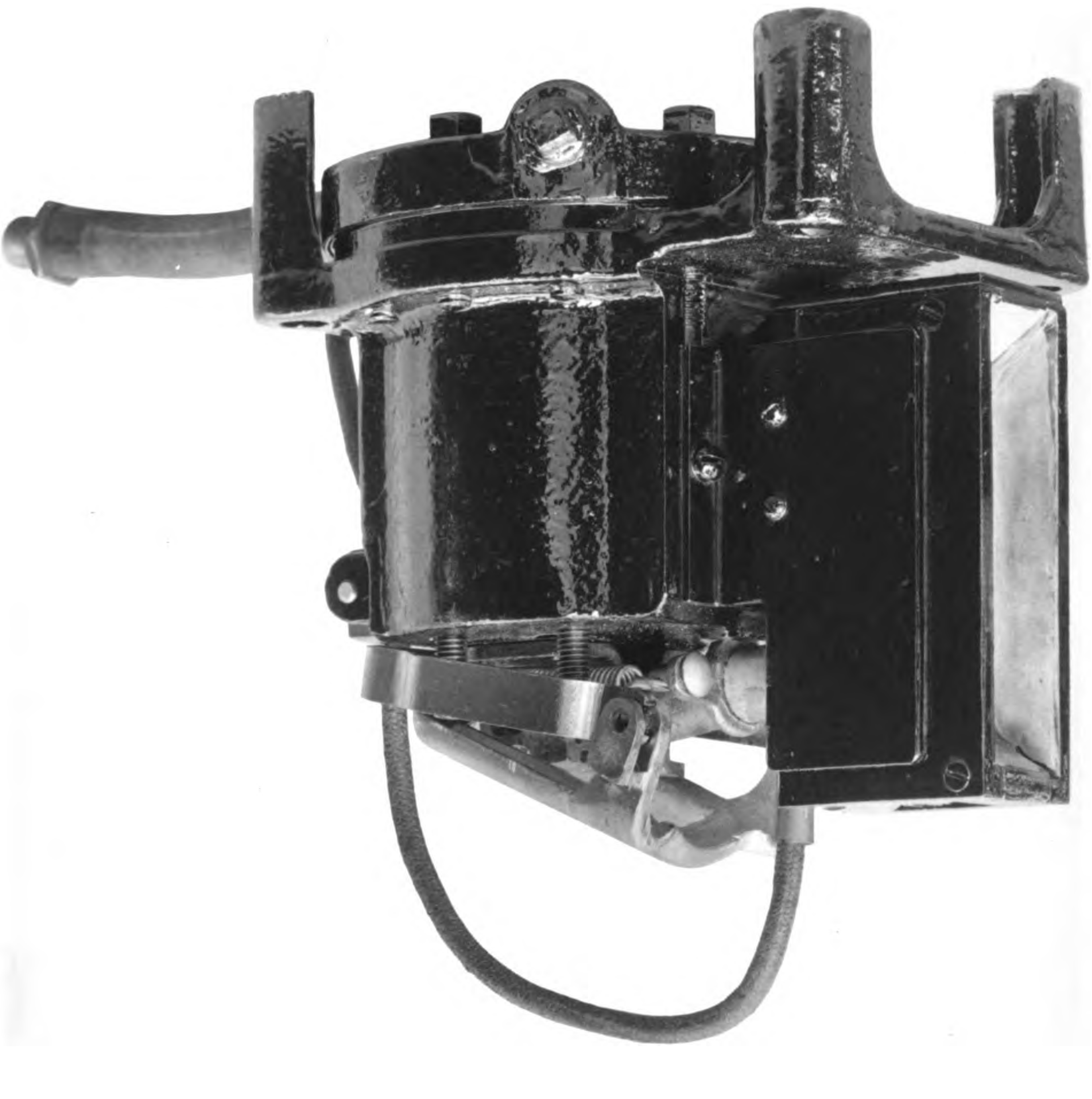
SUBJECT TO CHANGE. NOT FOR CONSTRUCTION UNLESS SPECIALLY APPROVED

202941 TYPE CP-19-B AIR COMPRESSOR.
OUTLINE.



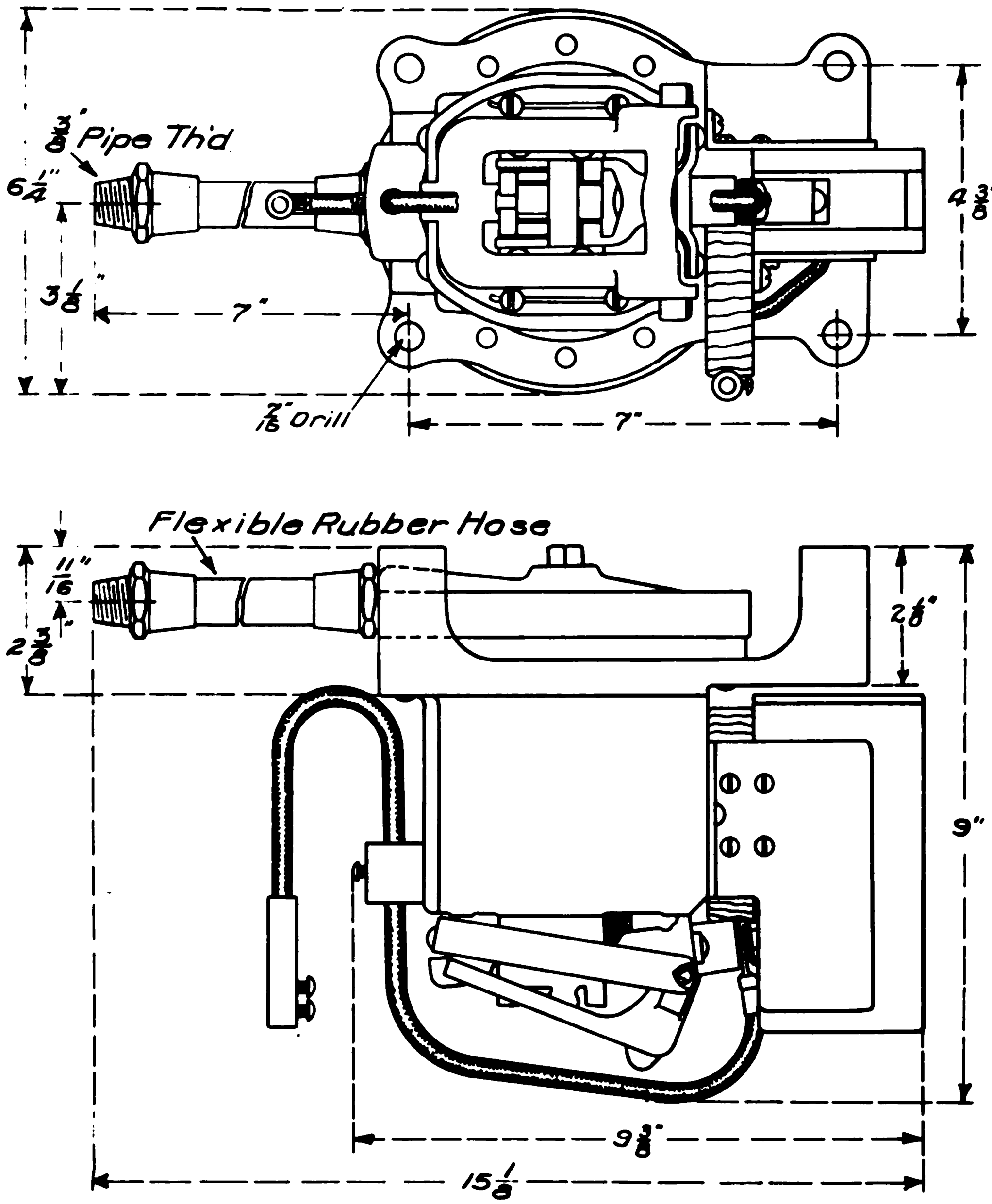
SUBJECT TO CHANGE. NOT FOR CONSTRUCTION UNLESS SPECIALLY APPROVED

202942 TYPE CP-19-B AIR COMPRESSOR.
SECTION.



300750 TYPE MB, FORM C GOVERNOR.

Dimensions of Type MB Form C Air Pump Governor



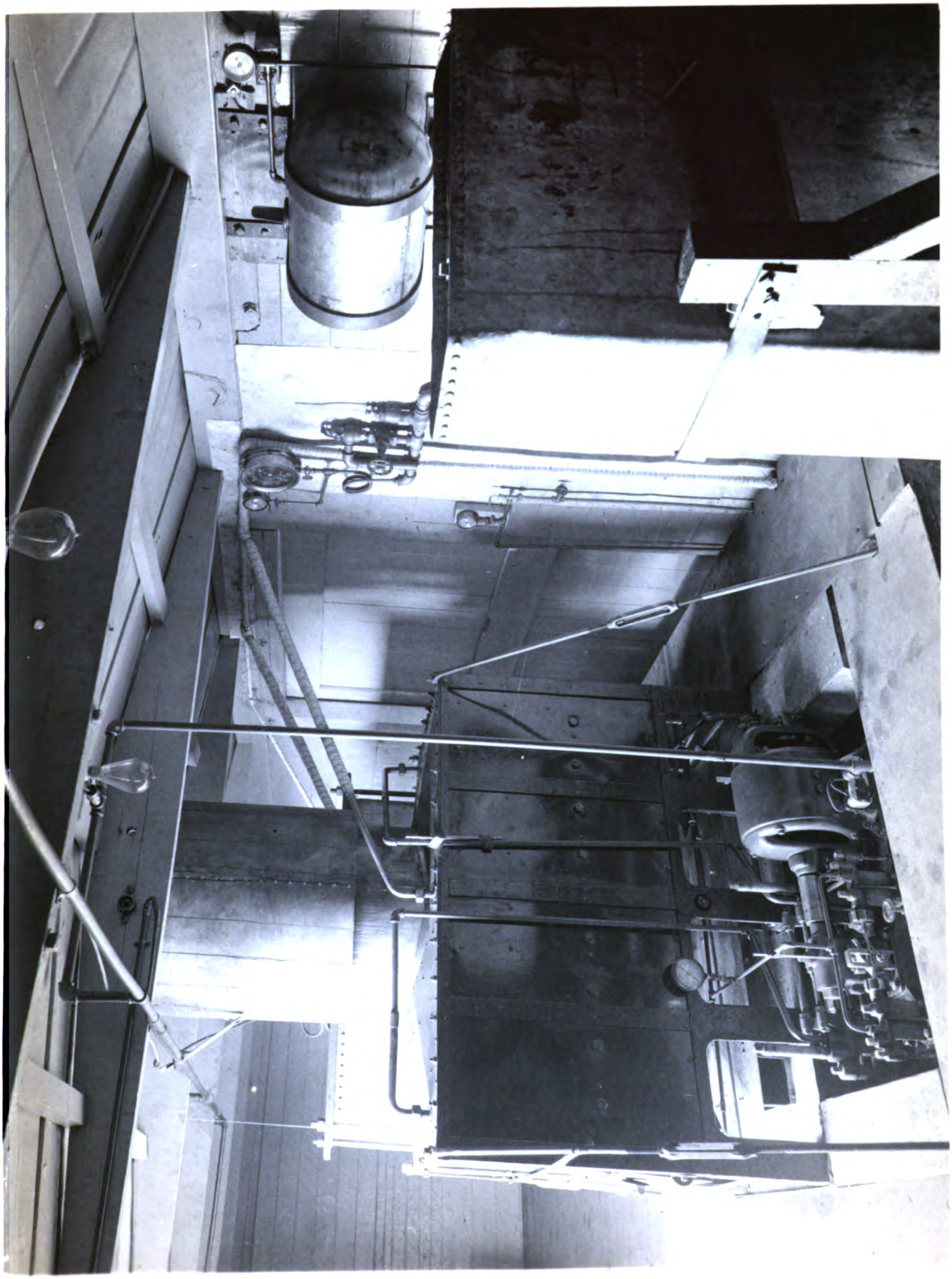
Changed 17 Dec. 1903

F. E. Carey

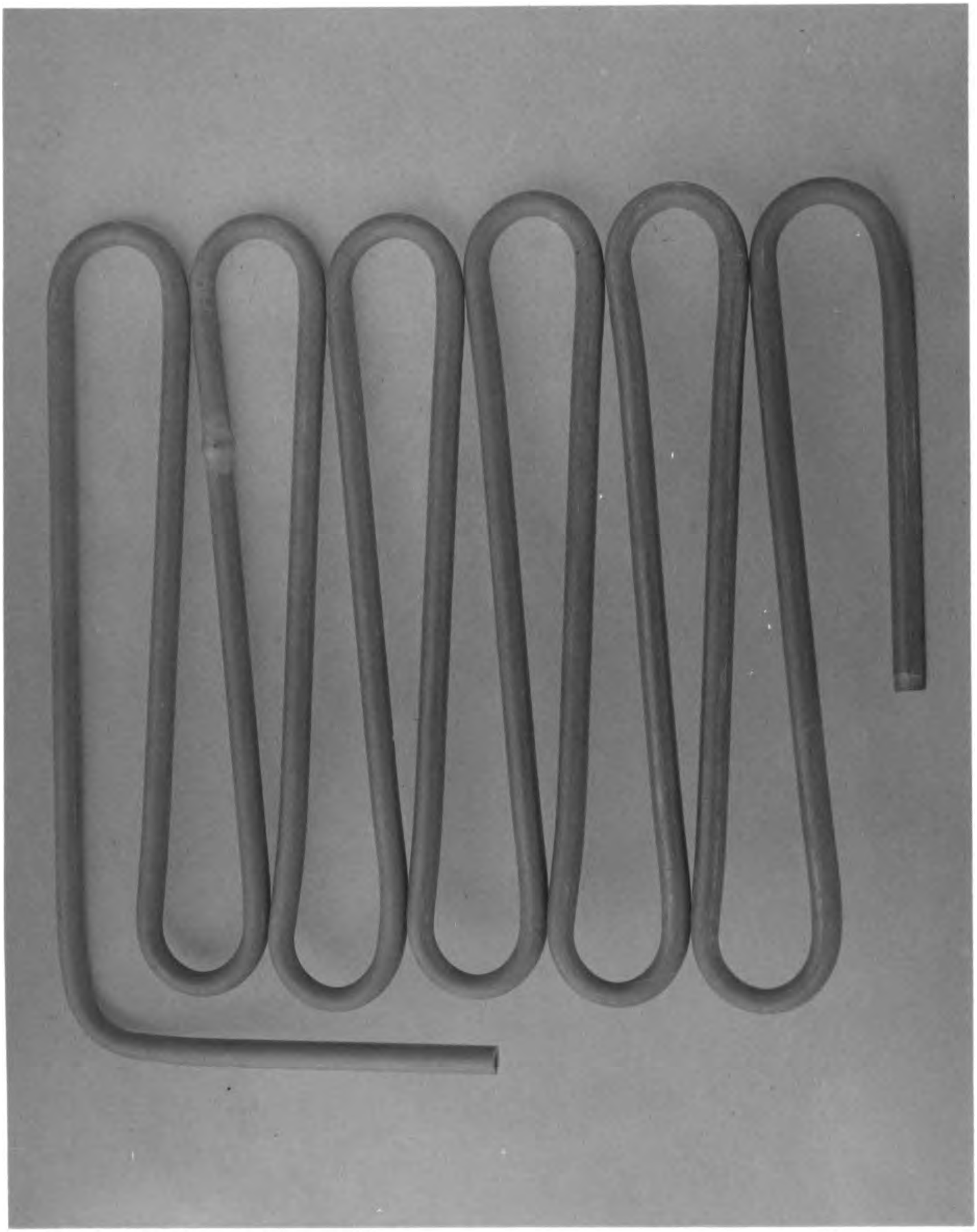
24 Sept. 1903

D.S. 4176

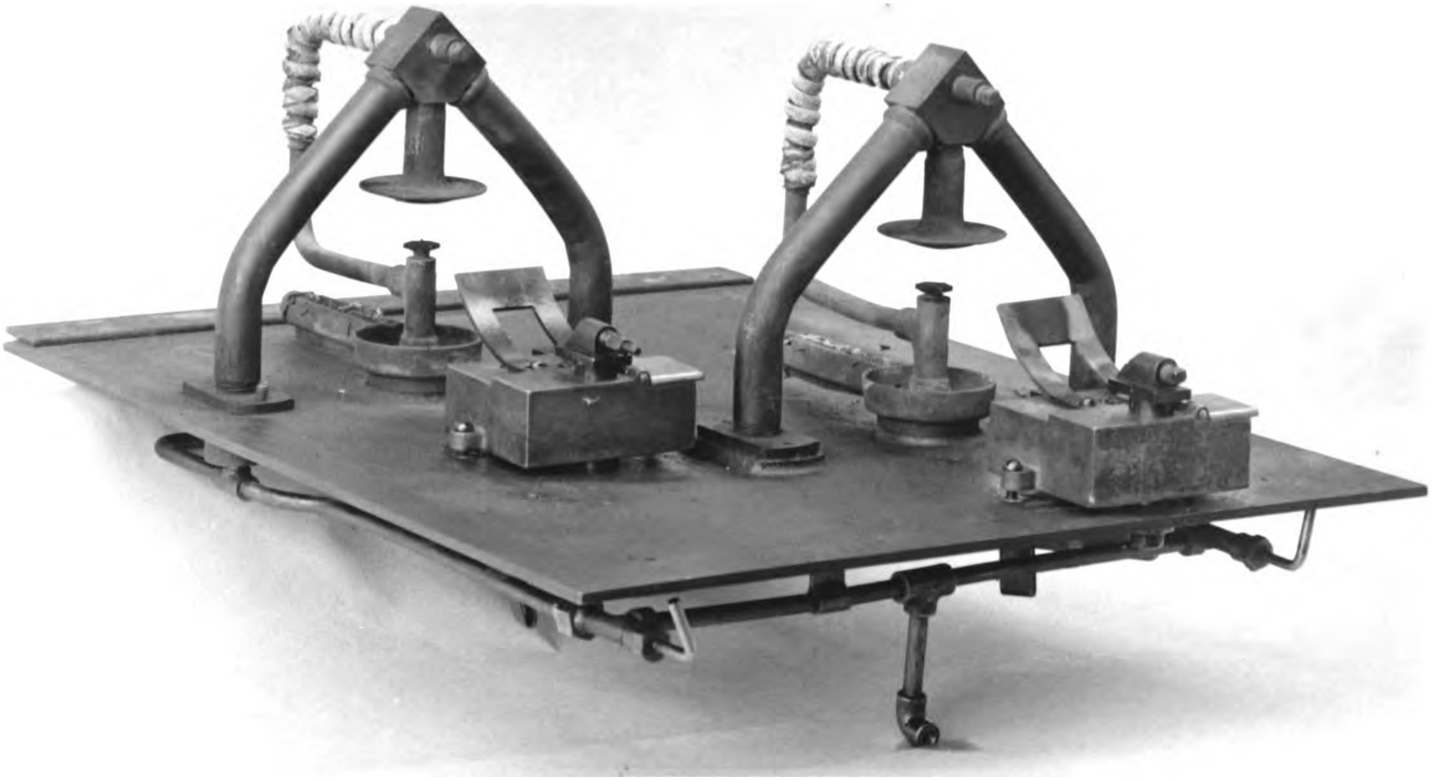
A.B.R.



202925 FLASH BOILER FOR HEATING TRAINS.
INSTALLED TEMPORARILY IN BOX CAR.



0757 STEAM GRID OF STEEL TUBING
FOR FLASH BOILER HEATER.



0750 KEROSENE BURNERS AND ATOMIZERS FOR FLASH BOILER HEATER.